A MANUAL

OF

ENGINEERING SPECIFICATIONS

AND

CONTRACTS,

DESIGNED AS A

TEXT BOOK AND WORK OF REFERENCE FOR ALL WHO MAY BE ENGAGED IN THE THEORY OR PRACTICE OF ENGINEERING,

BY

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"*Scientiarum omnium robur instar fascis illius senis; non in singulis bacillis sed in omnibus vinculo conjunctis.*—BACON.

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TO THE HONORABLE,

THE BOARD OF TRUSTEES,

OF THE

UNIVERSITY OF PENNSYLVANIA,

AND

CHARLES J. STILLÉ, LL. D.

PROVOST,

THIS WORK IS

VERY RESPECTFULEY

DEDICATED

BY

THE AUTHOR.

INTRODUCTION.

In preparing a piece of work for letting, the duties of the Engineer are manifold. He must first of all have a clear conception of the thing to be done, and must give graphical expression to this idea, both by drawings and writing. It then becomes necessary to inform himself as to the probable cost of the proposed work, and if within reasonable limits, and he desire to let it, he must next notify contractors, and others, by such public announcements as will reach the largest number of reliable parties.

It is thus seen that the preparation of the drawings, estimates, specifications and advertisements are all, duties of the Engineer, which he has heretofore been allowed to learn as necessity required, and often on the spur of the moment. But his duties do not end here; to insure the rapid and faithful execution of the work, he generally prepares the form of bid, with certain "instructions to bidders," giving restrictions with which they must comply to render their bids valid, and finally, to adopt a form of agreement which shall be approved by both parties to the contract.

The duties of the contractor are simply to examine drawings and specifications, or the site of the work, present his bid, and, if successful, sign the contract and furnish the required securities. The construction of the work is foreign to the object of this book. These six steps are developed more fully in the corresponding chapters which follow.

PREFACE.

In the course of their professional career, Engineers are frequently called upon to prepare papers connected with the letting of work by contract. Often devoid of instruction, without experience and with no works of reference at hand, it frequently happens that their efforts result in inconvenience and loss. Essential points are sometimes overlooked, and too great confidence is reposed in the good intentions of the parties. To aid in preventing such unfortunate results and to meet an acknowledged want in our schools for Engineers, the author has been induced to prepare this monograph on ENGINEERING SPECIFICATIONS and CONTRACTS, and has aimed to make it equally useful as a text book and work of reference. An effort has been made to present clearly all the essential elements connected with the letting of work by contract.

The several operations required have been systematically arranged, and the principles involved stated in their proper connections, and illustrated by a few typical forms carefully selected from the most reliable authorities.

To accomplish this object most effectively the entire operation has been divided into its six elements, as given under the headings to the several chapters.

It is not intended to make this work an exhaustive compendium of every possible form and condition, but to exhibit in the most concise manner the governing

principles in all operations between two or more parties. Hence a careful analysis of the several cases presented has been made, showing the items and essentials which should enter into ordinary contracts with the manner of uniting them to form a complete instrument. This analysis is rendered more apparent by the use of marginal references throughout the work and by a series of questions on the contents of each chapter.

Considerable difficulty was experienced in preparing the Code of Artisans' Rules for measuring work, since the little that exists in print on that subject is in such form as not to be generally applicable. The rules as given are the result of much correspondence and many interviews with experts. As prices for labor and materials are so variable no effort has been made to prepare lists, but an illustration is given of their use in the fifth section of the second chapter. For more complete information on this subject the inquirer is referred to the third volume of a work published by J. Haviland, in Philadelphia, 1829, entitled "The Builders' Assistant, including The House Carpenter's Book of Prices and Rules for Measuring and Valuing all their different kinds of Work" and also to the "Architects' and Builders' Companion:" Phila. 1875, by Frank W. Vogdes, Architect.

In the Engineering Specifications, Chapter III, cited as examples, much technical information is given which is not to be obtained from text books. It is therefore recommended that students should read them carefully, and for explanations of terms refer freely to the glossary specially prepared to accompany them. The questions

upon this chapter will be found very useful in a general review of the course.

To render the instruction as practical and interesting as possible, it has been the custom to require students at the University of Pennsylvania to perform all the operations for a special piece of work, such as the constructions of the model of a bridge, a tunnel, or other object, on a scale of about 1-24. Students should make the drawings, estimate quantities, and prepare bills of material, specifications, bids, and contracts. The bids may then be opened in presence of the section or class, and the work awarded to some member, selected as foreman to superintend its execution. It is not, however, necessary to carry the practice so far as the *construction of models.* Where facilities for such work do not exist it is recommended that the students be given special problems in constructions, as of a culvert, section of railway, either road bed or laying track, bridge or roof trusses to make estimates upon and prepare for letting. Such exercises prove very instructive, and compel an active interest in all collateral studies, by developing at once their practical applications. In conclusion the author gratefully acknowledges the information furnished by Genl. A. A. Humphreys, Chief of Engineers, U. S. A.; Col. Peter C. Haines, Secretary U. S. Light House Board; Genl. Wm. F. Raynolds, U. S. E. Engineer, Fourth Light District; Richd. K. Betz, and Jno. McClure, members of Carpenters' Company of Phila. and professional measurers; Messrs. Wilson Bros. & Co., Engineers and Architects; Hazel Wilson, C. E. Chief Eng. Penna. R.R.; Henry

S. Drinker, E. M.; Saml. L. Smedley, Esq. Chief Engineer and Surveyor, of Phila.; Rudolph Hering, C. E. Assist.; Jas. G. Hill, Supervising Architect, Washington; Wm. J. Twining, Maj. of Engineers, and many others; with such works of reference as Haswell, Trautwine, Spon, Molesworth, Hurst, Vogdes, and other hand books; Johnson's Universal Cyclopedia, Parson's Laws of Business, Vogdes' Mensuration, Tracy's Commercial Arithmetic, Robertson's Engineering Notes, Col. Lee's Tables, &c.

L. M. H.

UNIVERSITY OF PENNA.
TOWNE SCIENTIFIC SCHOOL:
October 15th, 1877.

PREFACE TO SECOND EDITION.

In submitting this Second Edition of his work to the profession, the author desires to acknowledge with thanks the many expressions of approbation that have been called forth by the first, and to state that he has carefully revised the entire work and added in Appendices A and B some new matter, which it is hoped will be found useful.

With these addenda and improvements this edition is offered to Engineers and Students—in the belief that the demand, which has established beyond a doubt the need of such a work in the past, will be continued, and even increased in the future.

L. M. H.

UNIVERSITY OF PENNA.,
Phila., Jan. 3, 1881.

CONTENTS.

CHAPTER I.

THE DRAWINGS.

Drawing is the art of representing graphically, objects or ideals, as they exist or appear to exist. Drawing defined.

The representation of objects as they exist, showing their forms, sizes and positions, is included in those subdivisions of the art known as *Orthographic Projections*, *Isometrical Perspective*, and *Shades and Shadows*. The representation of objects as they appear to exist is known as *Scenographic Projection*, *Linear* or *Aerial Perspective*. Classification.

To draw correctly, therefore, involves a thorough knowledge of Descriptive Geometry with its applications to the Arts and Manufactures. Its study should be insisted upon in all Technical Schools, as in addition to its direct use, it is particularly valuable in developing the inventive and perceptive faculties, which of all others are most useful to the practical engineer. Value of Descriptive Geometry as a study.

All objects possess two general characteristics—*form* and *color;* but the color, which serves merely to give variety and expression to the object, is limited by and contained within the form. It is to the latter therefore to which our chief care and attention should be directed in all drawings. Form and color. Form, the chief characteristic of objects.

Form is an universal language, and hence the necessity of resorting so largely to it in the representation of all tangible and visible objects. It avoids much ambiguity and a multiplicity of words, and is intended in the drawing to be a representation in miniature of the idea or thing to be delineated. Language of form, universal.

The scale is the expression of the ratio of the drawing to the object. Scale defined.

The value of a drawing depends, therefore, principally upon the accuracy of its outline, which should be made on as large a scale as convenient and not be confused by a mass of details. Simplicity and accuracy of outline, required.

To make a complete representation of a solid, at least *three projections* are necessary, *the plan*, *elevation* and *section*, but frequently many more are required, and in complex constructions there should be shown, firstly, the general views of the various parts properly assembled as a whole, either in linear or isometrical perspective or in projection, and secondly, the three or more projections of each of the parts or details, usually on a larger scale. To this latter class belong all "working drawings" which are always made to a scale, and to prevent any mistake which might arise from errors in the drawings, all distances and dimensions should be carefully written upon the parts to which they belong. The space intended to be embraced by the figures is indicated by dotted arrows extending outward from them, thus:

The three projections.

Working drawings.

Dimensions should be marked.

|<..........................24′ 6″..........................>|

|<...............................29′...............................>|

Should it happen that the dimensions marked do not correspond with the distances given by the scale, and it is impossible to determine from any source which is correct, preference should be given to the numerals, unless they are manifestly in error, and the work constructed in accordance therewith must be accepted.

Written dimensions to be taken as authority in cases of doubt.

The scale should be so large that the least dimension may be distinctly represented. It is desirable also to construct it upon the same sheet of paper with the drawing, that it may be subjected to the same variations from changes of temperature, moisture and other causes, and thus the ratio of the two remain constant. A detached scale upon a piece of paper of the same quality will be found very convenient and more accurate than the dividers, which are liable to slip or spring back as well as to injure the drawing. For small measurements the diagonal scale is the most accurate. Triangular box-wood scales are also very useful.

Selecting the scale and preserving its ratio to drawing constant.

Objections to the dividers.

Other scales.

Constructions in Architecture, Machinery or any works executed by artisans are usually represented by the duodecimal scales, whilst those for the engineer are ex-

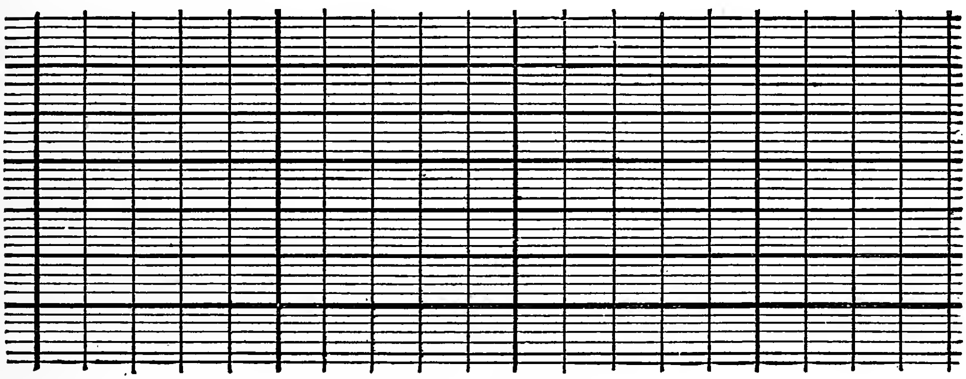
Decimal and duodecimal systems when used.

pressed in the decimal or metric system, but the rule is not absolute, and either may be used.

Vertical and horizontal scales frequently different.

The vertical and horizontal scales are not always the same, as it is frequently desirable to magnify the irregularities of surface lines as in profiles or longitudinal sections of earth, either above or under water, and to represent fluctuations of various kinds, as prices of materials, pressures, &c. For such purposes "profile" paper, ruled in various forms is published either in sheets or continuous rolls. For profiles of earthworks, the ratio of the vertical to the horizontal scale is usually as one to one hundred, but may be taken at one to fifty; one to ten or any other convenient fraction.

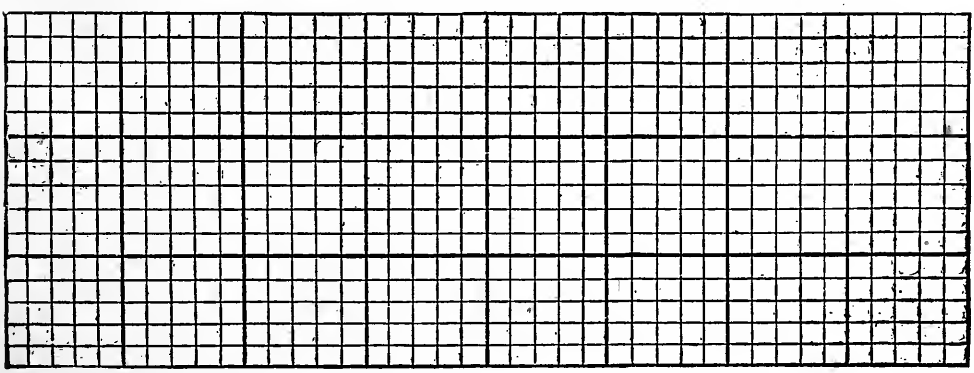
Description of profile papers.

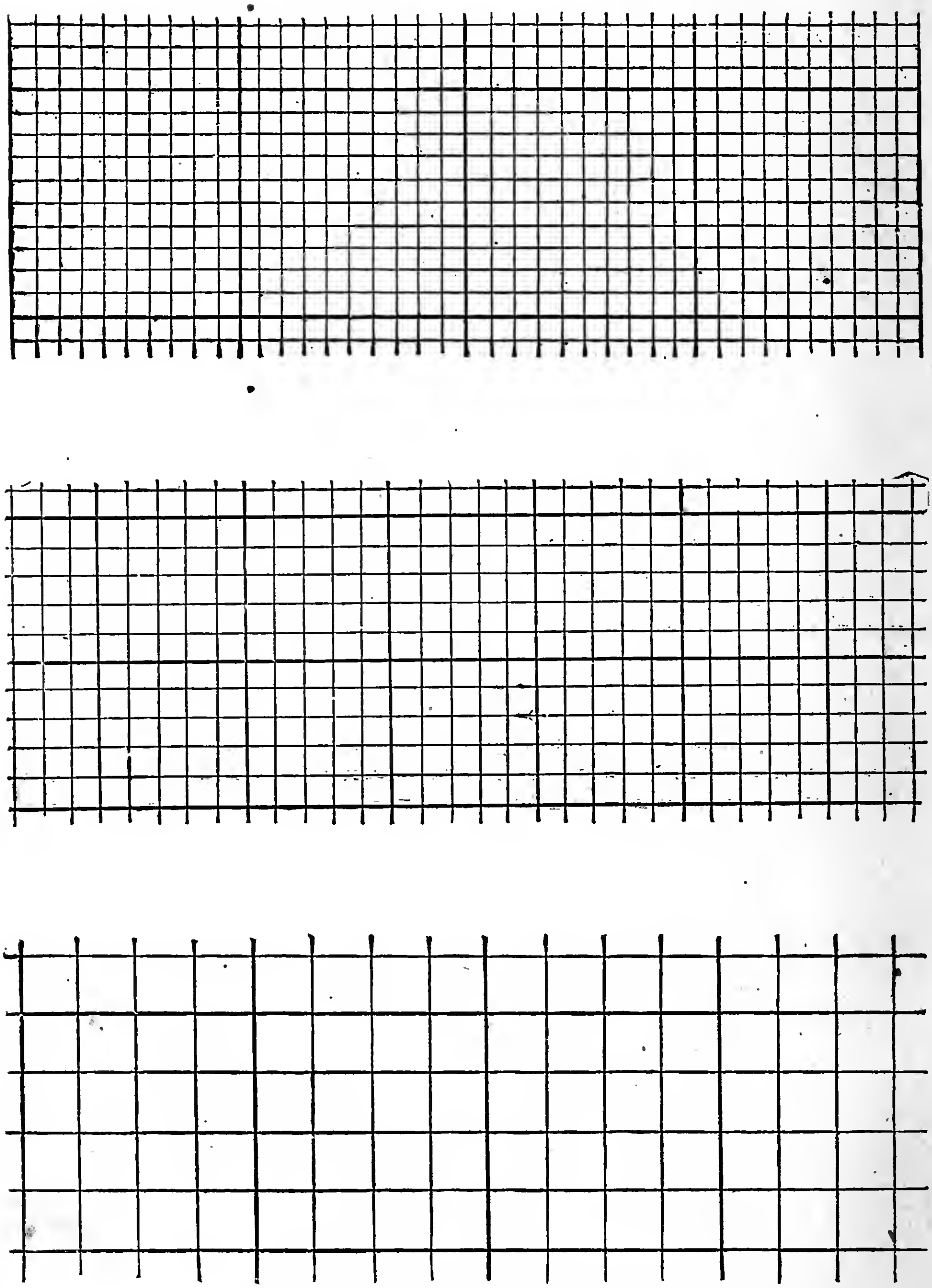


Sample, (The original is in red or green.)

Cross section paper.

Cross section paper is ruled in large and small squares, the ratio of the scales being as one to one. It is found very convenient for sketching and computations of sections, and is frequently bound up in book form for field work.



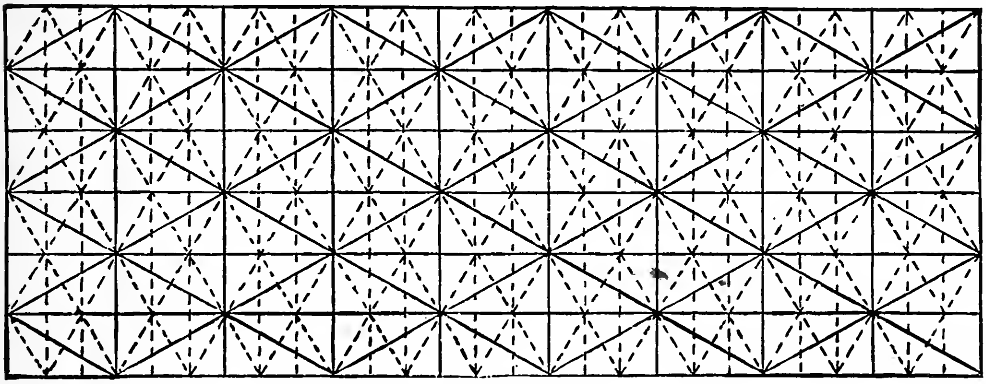


Samples. (The originals are in blue, green or red.)

Isometrical paper.

A new style of drawing paper recently patented has been designed to aid in making *isometrical* drawing. It is

printed in pale colors so as not to confuse the eye, and is covered by a net-work of full and dotted lines, as per sample:



Sample. (In pale drab.)

Light.
Direction of.
Lines of shade defined.
Application.

To avoid errors in reading or making drawings, some knowledge of the effect of light is necessary. It is generally assumed in linear representations of objects that the parallel rays of light enter from the upper left hand corner at an angle of 45°, so that all objects which project above a plane surface will cast shadows upon that plane, whilst all depressions in the plane will receive shadows from their edges. The edges casting the shadows are *lines of shade*, and should be drawn heavier than the remaining lines of the drawing. By carefully observing this distinction it is possible to determine at a glance whether a portion of a surface projects or recedes, for example:—

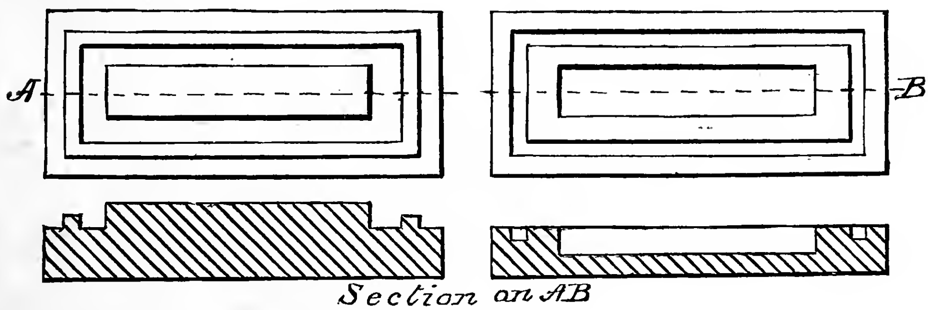


Illustration.

Explanation.

In the first panel the centre and the borders are raised and in the second depressed, as shown in the sections.

Rules for drawing shade lines.

A general law is also deduced from these principles, namely, that *in drawing projections, the right hand and bottom lines should be the heavier, and in recesses the left hand and upper lines the heavier.*

Section lines, or hatchings.

To render drawings still further intelligible all sections of solids should be shaded by a series of parallel lines called section lines or hatchings, drawn at regular intervals. In curved or irregular surfaces, the effect may be shown by parallel lines drawn at irregular intervals.

Colors—not generally required.

To represent timber and metals of various kinds, colors are sometimes used with good effect, but they are not generally required, as the specifications should indicate with sufficient clearness the nature of the materials.

To secure uniformity in the use of colors when desired, a code is hereto annexed :—

Conventional Colors.

Brass, Exterior	Gamboge
Brass, Interior	Dark Indian Yellow
Brick, Exterior	Lt. red with carmine
Brick, Section	Crimson lake or carmine
Brushwood	Green and bt. sienna, marbled
Buildings	Crimson lake
Buildings, shadows of	Indigo, bt. sienna and lake
Cast iron	Payne's gray
Clay or earth	Burnt umber
Concrete work	Sepia
Copper	Gamboge and crimson lake
Cultivated land	Bt. sienna
Earth and clay	Bt. umber
Fir timber	Indian yellow
Granite	Violet, carmine
Grass	Hooker's green
Gravel	Yellow ochre dotted with bt. sienna
Gun metal	Dark cadmium or orange
Iron, Cast	Payne's grey
Iron, Wrought	Prussian blue and indigo
Mahogany	Indian red
Meadow land	Hooker's green
Mud	Sepia or India ink
Oak timber	Bt. sienna, grained
Roads and streets	Yellow ochre
Sand	Yellow ochre
Sky	Cobalt
Slopes	Sepia with bt. umber
Steel	Indigo or Prussian blue and lake
Stone	Sepia and yellow ochre
Trees, Light	Gamboge and bt. sienna, on a green ground
Trees, Shade	Gamboge and indigo, on a green ground
Trees, Shadows	Bt. sienna and indigo, on a green ground
Uncultivated land	Green and bt. sienna, marbled
Vineyards	Purple
Water	Indigo
Wood, Exterior	Yellow ochre or raw sienna
Wood, Sections	Bt. sienna
Wrought iron	Prussian blue and indigo

Sizes of Drawing Papers in Sheets.

Antiquarian	53x31
Atlas	34x26
Columbier	35x23½
Demy	20x15¼
Double Elephant	40x27
Elephant	28x23
Emperor	68x48
Imperial	30x22
Medium	22¾x17½
Royal	24x19¼
Super Royal	27¼x19¼

Paper is also manufactured in continuous rolls of 36, 42, 54 and 59 inches in breadth and of various weights, qualities and colors. The light brown manilla is extensively used for working drawings. Hot pressed papers have a smooth surface; cold pressed, rough. The latter are generally preferred.

Hot and cold pressed.

The drawings to accompany a contract should be so full, complete and accurate as to leave nothing to the imagination or discretion of the contractor that may be shown on paper. All the sheets should be carefully designated by letters or numbers for convenience of reference, should contain a title, a *scale*, the *date* when finished, and name of the person who may be consulted in cases of doubt or errors, should they arise.

Requirements of drawings for contracts.

In addition to the above, maps should always show a meridian and the magnetic variation when it is possible to determine it. These last requirements are frequently overlooked.

For maps.

Every piece of work, however small, should be represented by drawings, that the artisan may have a distinct idea of what is to be done.

Necessity for drawings.

For Government works, the law of 15th July, 1870, is very explicit. It provides that,

"Before any new buildings for the use of the United States are commenced *the plans* and *full estimates* therefor shall be prepared and approved by the Secretary of the Treasury, the Postmaster General and the Secretary of the Interior; and the cost of each building shall not exceed the amount of such estimate."*

Law requiring plans and estimates for Government work.

The above law requires not only *drawings* but *estimates* in full, which shall be equal to the cost of the proposed structure. It is important therefore that the engineer or architect should have sufficient prescience based upon experience to include and provide for every item or contingency that may arise in the progress of the work, that his estimates may not fall short of the actual cost, as is too often the case. The principal items entering into estimates with the manner of working them up will be found more fully developed in the succeeding chapter.

Complete estimates required

* Revised Statutes U. S. Section 3734.

QUESTIONS ON THE FIRST CHAPTER.

Page 1. Define drawing. What are its sub-divisions? State the general characteristics of all objects. Which is most important? Why is so much stress laid upon correct outline? What is the scale?

Page 2. What are the views given in projections? What are working drawings? How are dimensions indicated? How are the correct dimensions determined? How is the scale determined and where should it be placed? Why are dividers objectionable? When are decimal and duodecimal scales used?

Page 3. Why are the vertical and horizontal scales sometimes different? What are profiles? What are cross sections?

Page 5. In what direction is the light supposed to enter? What is the distinction between shade and shadow?

Page 6. Give the rule for drawing shade lines. What are section lines? When may colors be used?

Page 7. What are the requirements in drawings for contract work? for maps? Why are drawings necessary? What is the U. S. law concerning drawings and estimates?

CHAPTER II.

"For which of you intending to build a tower, sitteth not down first, and counteth the cost, whether he have sufficient to finish it. Lest haply, after he hath laid the foundation, and is not able to finish it, all that behold it begin to mock him, saying, This man began to build, and was not able to finish."—St. Luke xiv: 28, 29, 30.

Estimates and Measurements.

That the engineer may be able to present the case properly in his advertisements as well as to determine for his own guidance in letting, the amount of work to be done, it will be necessary for him to prepare from the drawings or from surveys approximate estimates of quantities as well as of costs. In making up such estimates it must not be forgotten that there are other items of expense than mere *cost of materials* and *labor.* To these must be added the expense of *engineering*, *superintendence*, the tools, machinery, instruments, buildings, &c., known as the "*plant*," *interest* of money invested, a fair allowance for *contractor's profit*, *wear and tear* of tools and machinery, *insurance* if necessary, and a percentage for *contingencies*, such as damage to property or to the work itself from the elements or from accidents.

Need of a preliminary estimate.

Elements to be embodied in estimates.

Some of these quantities are functions of others which are very variable, as prices and animal power, systems of working, &c., so that such tables of statistics would be an incumbrance to this work, especially as they can be so readily referred to in numerous engineering hand-books, but the more constant data used in the calculation of quantities will be found serviceable for reference in this connection, and are therefore introduced in as condensed a form as possible.

Section I.

Formulæ for Computing Lines, Surfaces and Solids.

Lines.

Ratio of diagonal to side of square $1:\sqrt{2}=1.414=\frac{10}{7}$ nearly.
Side of inscribed square $:R::\sqrt{2}:1$.
Side of inscribed equilateral triangle$:R::\sqrt{3}:1$.
Side of inscribed regular hexagon$=R$.
Side of inscribed regular decagon$=0.618\ R$.
For any part of triangle $a:b$ or $c::\sin A:\sin B$ or $\sin C$
$\begin{cases} a,\ b,\ c=\text{sides.} \\ A\ B\ C=\text{angles opposite.}\end{cases}$

Circle.

Ratio of circumference to diameter$=3.1415926+=\frac{355}{113}=\pi$.
Circumference$=2\ \pi\ R,=\pi\ D$ where R=radius, D=diameter.
Length of arc$=\frac{a\ \pi\ R}{180}$, where a=the number of degrees in the arc; or nearly$=\frac{8c'-c}{3}$ c being the chord of the arc and c' (the chord of half the arc)$=\sqrt{\frac{1}{4}c^2+\text{ver}\ \sin^2}$. Length of Circumference. Arc.

Diameter$(=2R)=\frac{\text{Circumference}}{\pi}=\frac{\text{Circum}}{3\cdot1416}$. Diameter.

Ellipse.

Perimeter$=\frac{199}{200}\ \pi\ \sqrt{\tfrac{1}{2}(a^2+b^2)}$ nearly; a and b being axes. Length of Ellipse.

Parabola.

Length of arc cut off by a, double ordinate$=$ $2\sqrt{y^2+\frac{4}{3}x^2}$, where y=the ordinate and x=the abscissa referred to the vertex as an origin. Length of Parabola.

Hyperbola.

Length of arc$:2\,y::(19\ a^2+21\ b^2)\,x+15\ a\,b^2:(9\ a^2+21\ b^2)\,x+15\ a\,b^2$ where x=abscissa, $2\,y$=double ordinate, a and b=transverse and conjugate axes respectively. Length of Hyperbola.

SURFACES.

1 Area of *Triangle*$=\frac{b\,h}{2}$ where b=base and h=height.

2 Area of *Triangle*$=\frac{a\,b \sin C}{2}$, a and b=sides, C included angle. Triangle.

3 Area of *Triangle*$=\sqrt{s(s-a)\,(s-b)\,(s-c)}$: a, b and c=sides, s=their half sum.

1 Area of *Parallelogram*$=b\,h$, where b=base, h=height.

2 Area of *Parallelogram*$=a\,b \sin C$, a and b sides C included angle. Parallelogram.

3 Area of *Parallelogram*$=2\sqrt{s(s-a)\,(s-b)\,(s-c)}$ where c is the diagonal joining extremities of a and b and s the half sum.

1 Area of *Trapezium*$=\frac{b+b'}{2}\,h$, b and b'=parallel bases. Trapezium.

2 Area of *Trapezium*$=\frac{b+b'}{2}\,l \sin C$ where l=length of one of the oblique sides; and C the angle between it and one of the bases.

Any *Regular Polygon*$=\dfrac{n\left(\frac{a}{2}\right)^2}{\tan\frac{180^\circ}{n}}$ a=length of one side. n=number of sides.

Area of *Circle*$=\pi\,R^2$, R= radius, $\pi=3.1416$. Circle.

Area of *Ellipse*$=\pi\,a\,b$; $2\,a$=transverse, $2\,b$=conjugate axis. Ellipse

Surface of *Right Cylinder*, excluding bases$=2\,\pi\,R\,h$ Right Cylinder.

Surface of *Sphere*$=4\,\pi\,R^2$. Sphere.

Surface of *Zone* of two bases$=2\,\pi\,R\,h$, h=height. Zone.

Surface of *Zone* of one base$=\pi\,c^2$ where c=the chord of the arc generating the zone.

Surface of *Right Cone*$=\pi\,R\,l$, l=slant height or element. Right Cone.

Frustrum of Cone$=\pi\,l'\,(R+r)$, l'=slant height Frustrum of Cone.

VOLUMES.

Of any *Prism*$=B\,h$, B=area of base, h=height. Prism.

Of a *Rectangular Parallelopipedon*$=a\times b\times c$= product of edges. Rect. parallelopipedon.

Of a *Cube*$=a^3$. Cube.

Of a *Pyramid*$=\frac{B\,h}{3}$, B=base, h=height. Pyramid.

Of a *Cylinder*$=\pi\,R^2\,h$, h=height. Cylinder.

Of a *Cone*$=\frac{\pi\,R^2\,h}{3}$, h=height. Cone.

Of a Frustrum of *any Cone*$=\frac{h}{3}\,(B+b+\sqrt{Bb})$, B and b=areas of bases. Frustrum of Cone.

Of a Frustrum of a *Regular Pyramid*, (same as above.) Frustrum of Pyramid.

Of an *Ungula*, when the section passes through the opposite extremities of the bases$=\frac{D^2-d\sqrt{D\,d}}{D-d}\,D\,h\;.2618$ where D and d=diameters of lower and upper bases, h=height. Ungula.

Of the *Wedge or cuneus*$=(2\,l+e)\frac{h\,b}{6}$, where l= length of back or base and b its breadth; e=the length of the edge and h=the height. Wedge.

Of the *Prismoid** Prismoid.

$$=\left\{(b+r\,h')\,h'+(b+r\,h)\,h+4\left(b+r\times\frac{h+h'}{2}\right)\frac{h+h'}{2}\right\}\frac{l}{6}$$

b=breadth of road bed; h=perp. depth of cut at higher end; h'=same at lower end; l=distance between sections and r= ratio of height to base of slope.

Of the *Sphere*$=\frac{\pi}{6}\,D^3$ or $\frac{4\,\pi\,R^3}{3}$, D=(2 R)= diameter. Sphere.

Of the *Segment of a Sphere* $\frac{\pi}{2}\,(R^2+r^2)\,h+\frac{1}{6}\,\pi\,h^3$, where R and r=radii of the bases and h=height. If but one base, r becomes zero. Segment of Sphere.

Of the *Spherical Pyramid*$=\frac{1}{3}\,R\,s$, s=area of spherical polygon forming the base and R=radius of sphere. Spherical pyramid.

Of the *Spheroid*$=\frac{\pi\,a^2\,b}{6}$, a=the revolving, b the fixed axis. Spheroid.

Of the *Frustra of Spheroids.* Frustra of Spheroids.

(A) When the ends are cut off by planes *perpendicular* to the axis of rotation$=(a^2+c^2)\,\frac{\pi\,l}{12}$; a=revolving axis c=diameter of either end; l=length of frustrum.

* For a much simpler formula recently discovered the student is referred to a work on "Formulæ for R. R. Earth Work," by Davis. For sale by D. Van Nostrand, New York, 1877.

(B) When the sections are made by planes parallel to the axis of rotation and to each other $=(2\,ab+c+d)\,\frac{\pi\,h}{12}$; a and b are the diameters of the middle and c and d of the end sections.

Of the *Paraboloid of Revolution* $=\frac{B\,h}{2}$; B=area of base, h=height. Paraboloid.

Of the *Hyperboloid of Revolution* $(a+h):(a+\frac{2}{3}h)::\frac{\pi R^2 h}{2}:x$, a=trans. axis of generating hyp; h=height; R=radius and x=required volume. Hyperboloid.

The Five Regular Solids.

Regular polyhedrons.

Of the *Tetraedron* $.11785\,s^3=\frac{s^3}{12}\sqrt{2}$.
Of the *Hexaedron* $=S^3$.
Of the *Octaedron* $=.471404\,S^3$.
Of the *Dodecaedron* $=7.6631\,S^3$.
Of the *Icosaedron* $=2.1817\,S^3$ where s=length of one edge.

Of the *Circular Ring* $D_e\,T_h^2\times 2.4674$ where D_e =exterior diameter, T_h=thickness of ring=$(R-r)$.* Circular ring.

Section II.

Standard Units and their Functions.

In all contracts for quantities of material no ambiguities are allowable, but the precise amounts should be clearly set forth. There is much room for misunderstanding in the ordinary use of terms, as for instance, a ton may be 2240 or 2000 lbs; a perch, 22, 24¾ or 25 cub. ft.; a month, lunar or calendar; a year, Julian or Gregorian; a bushel, heaped or struck; a working day, 10 or 8 hours, or "from daylight 'till dark," &c. To prevent any uncertainty as to the meaning of the terms it is necessary to refer all amounts, if possible, to some invariable standard unit as a lineal, square or cubic yard or foot, a pound or an hour.

Exact amounts should be stated.

Ambiguities.

A well defined standard should be adopted.

* The above are the formulæ most frequently referred to in mensuration. They are compiled chiefly from Col. Lee's Tables, Professional Papers No 12, Corps of Engineers and Vogdes' Mensuration. For additional information see Trautwine or Haswell's Hand Books.

There are certain conventional methods of measuring Artisans' work requiring allowances to be made for workmanship, which will be explained hereafter.

The United States and English measures of *length* and *weight*, of the same denomination are practically equal, but there are wide differences between the same denominations of liquid and dry measure. U. S. and British measures of length and weight.

The British standard of length, the simple seconds pendulum, 39.1393 ins. long, having been destroyed by fire in 1834, it was found practically impossible to restore it, so that the British yard is about 1-14 of an inch in 100 ft. or 3⅔ ins. in a mile shorter than that of the United States, thus accounting for the difference between the British and American scientists' estimates of the length of a metre, a degree of longitude, a nautical mile, &c. Difference between them.

To convert British linear dimensions into American, multiply by 1.000058, and American into British, multiply by .999942. Rule for reducing one to the other.

U. S. Measures of Length.

The *standard* unit is the *yard.*

TABLE OF EQUIVALENT LENGTHS.

Ins.″	Feet (Ft)	Yards. (Yds)	Poles (Ps)	Furlongs. (Fs)	Statute Miles. (Ms)	League. (L)
12	1.	$0.\dot{3}33$	$0.\dot{0}60\dot{6}$	$0.001\dot{5}1\dot{5}$	0.00018939	
36	3.	1.	0.1818	0.004545	0.00056818	
198	16.5	5.5	1.	0.025	0. 003125	
7920	660.	220.	40.	1.	0.125	
63360	5280.	1760.	320.	8.	1.	
190080	15840.	5280.	960.	24.	3.	1.

Miscellaneous.

A point=1-72 of an inch. A line=6 points=$\frac{1}{12}$ inch. A palm=3 inches. A hand=4 inches. A span=9 inches. A fathom=6 feet. A cable's length=120 fathoms=720′. Miscellaneous equivalents of length.

A *statute* or *land* mile=7⅓ cables=.86755 nautical miles=1609.315 metres.

A *geographical* or *nautical mile* or "*knot*"=1 min. of longitude on the equator, at the sea level=1.152664 statute miles=1855.11 metres=2028.69 yds.=6086.07 ft.

One degree at the eq.=69.16 or $69\frac{1}{6}$ statute miles.

One minute of *latitude* at the equator (sea level)=6046 ft.

One minute of *latitude* at the pole (sea level)=6107 ft., giving a mean of 6076½ ft. which is sometimes used.

The length of a degree of *longitude* decreases towards the poles as the cosine of the latitude and may therefore be found by multiplying $69\frac{1}{6}$ by cos L., (or for table of computed values see Trautwine p. 75.)

For *land measures* the Gunter's chain 66 ft. long is generally used, consisting of 100 links of 7.92 inches each. but for road, railroad and canal surveys the engineers chain of 100 or 50 ft. is taken as the unit. The parts of the Gunters chain are,

TABLE OF SURVEYORS MEASURE.

Inches.	Feet.	Links.	Poles.	Chains.	Furlongs.	Miles.
7.92	0.66	1.	0.04	0.01	0.001	0.000125
198.	16.5	25.	1.	0.25	0.025	0.003125
792.	66.0	100.	4.	1.	0.1	0.0125
7920.	660.	1000.	40.	10.	1.	0.125
63360.	5280.	8000.	320.	80.	8.	1.

As the *Metric System* was legalized by an Act of Congress, dated July 28, 1866, as a recognized standard of Weights and Measures in this country, it is thought proper to introduce it here, although it has not yet come into general use. The *metre* is the *unit.* Metric System.

FRENCH MEASURES OF LENGTH.

Equivalents.	Millim.	Centim.	Decim.	Metre.	Decam.	Hectom.	Kilom.	Myriam.
	0.001 m.	0.01 m.	0.1 m.	1. m.	10. ms.	100. ms.	1000. ms.	10000.ms
In.	.0393704	.393704	3.93704	39.3704	393.704	&c.		
Ft.		.0328 &c	.328087	3.28087	32.8087			
Yd.	&c.			1.09362	10.9362	109.362	1093.62	10936.2
Ms.						.06213	.6213	6.2134

Road measures.

Spanish Measures of Length.

In Mexico the metric system was established in 1856. The old measures are Spanish; the legal unit being the vara of Burgos =32.91 inches or 835.9 m m. The vara in actual use in AMERICA is, however, 33.385 in.=847.96 m m.=.84796 ms.

TABLE OF EQUIVALENTS.

Puntos.	Lineas.	Polgardas.	Sesmas.	Pies.	Varas.	Estadal.	U. S. Inch.
12	1						0.077
144	12	1					0.927
864	72	6	1				5.564
1728	144	12	2	1			11.128
5184	432	36	6	3	1		33.385
20736	1728	144	24	12	4	1	133.540

(Note. For equivalent itinerary measures in the principal foreign countries see Lee's Tables, Pages 18 and 19.)

TWO DIMENSIONS.

Surface Measures.

The *unit* for small areas is a *square foot*. **Superficial units.**
The *unit* for extensive areas is an *acre* or a *square mile*.

Square Measure is composed of the following equivalents:

TABLE FOR SQUARE MEASURE.

Sq. ins.	Sq. feet.	Sq. Yds.	Poles.	Roods.	Acres.	Sq. M.
144.	1.	0.1111	0.00367	0.0000918	0.00002296	
1296.	9.	1.	0.033058	0.0008265	0 0002066	
39204.	272.25	30.25	1.	0.025	0.00625	
1568160.	10890.	1210.	40.	1.	0.25	
6272640.	43560.	4840.	160.	4.	1.	
4014489600.	27878400.	3097600.	102400.	2560.	640.	1.

Miscellaneous.

16 sq. rods or poles=1 sq. chain. $2\frac{1}{4}$ sq. chains =1 rood. 10 sq. chains=1 acre.

Miscellaneous relations.

A *Government Section* of land is one mile square and contains 1 sq. mile=27,878,400 sq. ft.$=(5280)^2$ &c.

An acre is=to a square whose side is 208.71 ft. long.

A half acre is=to a square whose side is 147.581 ft. long.

A quarter acre is=to a square whose side is 104.355 ft. long.

French Measures of Surface.

The *square metre* is the *unit.*

TABLE OF FRENCH SURFACE MEASURES.

	Val. in Sq. Metre.	In U. S. sq. ins.	Sq. ft.	Sq. Yds.	Acres.
Sq. Millimetre.	.000001	.001594	.00001076	.0000012	
Sq. Centimetre.	.0001	.154988	.00107631	.0001196	
Sq. Decimetre.	.01	15.4988	.10763058	.0119589	
Sq. Metre or Centare.	1.	1549.88	10.763058	1.195895	.000247
Sq. Decametre or are.	100.	154988.	1076.3058	119.5895	.024709
Hectare	10000.	....	107630.58	11958.95	2.47086
Sq. Kilometre.	100000.	.38607 sq. m.	10763058.	1195885.	247.086
Sq. Myriametre.	10000000.	38.607 "	....	....	24708.6

B

Spanish Surface Measures.

The *unit* is the *fanegada* which is=1.5871 acres=0.642563 hectare.

The multiple being 50 fanegadas=1 yugada=79.355 acres.

Three Dimensions.

Cubic or Solid Measure.

The *standard unit* for mineral substances generally is the *cubic yard.* U. S. units of volume.

The *units* of capacity are: for liquids, the *gallon*, and for dry measure, the *bushel.*

TABLE OF SOLID MEASURE.

Cub. Ins.	Cub. Ft.	Cub. Yds.	Cords.
$12^3=$ 1728	1		
46656	$3^3=27$	1	
221184	128	4 20-27	1

Notes.

1 cord of fire wood piled, is 8 ft. long, 4 ft. wide and 4 high making 128 cub. ft. Miscellaneous measures.

1 chaldron of coal=57.25 cub. ft.=36 bushels.

The U. S. Government Engineers generally estimate *stone* by the *cord; sand* and *earth* by the *cubic yard; timber* by the *cubic foot*; *sawed timber*, joists, planks, scantling, &c., by the *superficial foot board measure, b. m.* containing 144 *cub.* in.; and *iron* by the *pound.* U. S. Engineers units.

A *perch* of masonry by quarrymen's measure is 16½ ft. long, 1½ ft. wide and 1 ft. thick=24¾ cub. ft. in the pile. It is generally taken at 25 cub. ft.; and some- The perch by quarrymen's and mason's measures.

times at 22 as in *mason's* measure where it is 16½ ft. long, 16 ins. wide and 12″ high measured in the wall.

Least allowable breadth 16″

Stone walls less than 16″ thick are assumed to have that breadth in estimating workmanship. To avoid any misunderstanding it is better to express the volumes in cubic yards or cords, which are becoming recognized standards in contract work instead of in perches as formerly.

Best units are cubic yards or cords.

Measures of Capacity.

Units of capacity.

The *standard units* are the *Winchester bushel* and the wine *gallon*.

Dimensions, &c., of bushel.

The *bushel* is a cylindrical vessel 18½ ins. in diameter and 8″ deep, containing 2150.42 cubic inches or 1.24446 cub. ft. of distilled water, and weighing 543,391.89 standard grains or 77.627413 lbs. Avoirdupois. When "heaped" the cone must be at least 6″ high making the *heaped bushel*=1¼ "struck" bushels=5 pks.=1.555 cub. ft.

Heaped bushel.

The relations in *Dry Measure* are,

TABLE FOR DRY MEASURE.

Pts.	Qts.	Pks.	Bush.
2=	1.	0.125	0.03015
16=	8.	1.	0.25
64=	32.	4.	1.

The gallon in Dry Measure contains $268\frac{4}{5}$ cub. in., but is seldom used.

The relations in *Liquid Measure* are,

TABLE FOR LIQUID MEASURE.

Gills.	Pts.	Qts.	Gal.	Hhd.	Pipes.	Tun.
4.	1.					
8.	2.	1.				
32.	8.	4.	1.			
2016.	504.	252.	63.	1.		
4032.	1008.	504.	126.	2.	1.	
8064.	2016.	1008.	252.	4.	2.	1.

Notes.

The *gallon* contains 231 cub. in. of distilled water weighing 58,372.2 grains or 8.3389 lbs. avoirdupois. Dimensions of the gallon.

In Beer Measure 54 gallons make 1 hhd.

A barrel of oil contains 42 gallons.

In Massachusetts 32 gallons make a bbl. In some States 31½, and in others from 28 to 32.

A *tierce*=42 gallons and *two* tierces=one *puncheon.* Tierce and puncheon.

Apothecaries divide the gallon into 8 pints; the pint into 16 ounces; the ounce into 8 drams; and the dram into 60 minims or drops. Apothecaries liquid measure.

French Measures of Capacity.

The *litre* is the unit=61.0165 cub. in.

TABLE OF EQUIVALENTS.

Names.	No. of litres.	Cubic ft.	Cubic measure.	Dry measure.	Liquid measure.
Myriolitre or Decastere.	10,000	353.105	10 cub.metres.	283.742 bush.	2641.41 gals.
Kilolitre or Stere.	1000	35.3105	1 "	1.3078 cub. yds.	264.141 "
Hectolitre or Decistere.	100	3.53105	0.1 "	2.83742 bush.	26.4141 "
Decalitre or Centistere.	10	.353105	10 decim.	283742 "	2.64141 "
		Cubic ins.			
Litre or cubic decimetre.	1	61.0165	1 "	.908 quarts	1.05656 quarts.
Decilitre.	0.1	6.10165	0.1 "	.1816 pints. 6.1022cub.ins.	.84525 gills.
Centilitre.	.01	.610165	10 cub.centim.	.01816 pts. .61022 cub. in.	.084525 "
Millilitre or cub. centimetre.	.001	.061016	1 "	001816 pts 0612 cub. in.	.00845 "

Spanish Liquid Measures.

The cantara or *arroba* is the *unit.*

The arroba mayor, for wine=4.079 gals.=15.44 litres.

The arroba menor, for oil=3.186 gals.=12.06 litres. The submultiples are,

Copas.	Quartillos / Cuartillos.	Azumbre.	Arroba.
4	1		
16	4	1	
128	32	8	1.

Spanish Dry Measure.

The fanega, the unit is=1.5551 bushs.=54.8 litres.

Ochavillos.	Racious.	Quartillos.	Medios.	Almudes.	Fanegas.	Cahiz.	U. S. bushels.
4	1						0.0081
16	4	1					0.0324
32	8	2	1				0.0648
64	16	4	2	1			0.1296
768	192	48	24	12	1		1.5551
9216	2304	576	288	144	12	1	18.6612

WEIGHTS.

The standard unit of weight is the pound avoirdupois; the only legalized unit is the pound Troy. **Units of weight.**

AVOIRDUPOIS WEIGHT.

Drams.	Ounces.	Pounds.	Quarters.	Cwt.	Tons.
16	1	0.625	.025	.00625	.0003125
256	16	1.	.04	.01	.0005
6400	400	25.	1.	.25	.0125
25600	1600	100.	4.	1.	.05
51200	32000	2000.	80.	20.	1

Notes.

The *ton* of 2240 lbs. known as the *old* or *long ton* is the standard used at the custom houses of the U. S. Government but the short ton is now the one intended unless otherwise specified. Iron is sold by the long ton. Old and new ton.

The *avoirdupois pounds* of Great Britain and the U. S. are equal to each other and to the weight of 27.7015 cub. inches of distilled water at its max. density—barometer 30 ins.—volume (3.0258 ins. ³). U. S. and British pound equivalents.

Troy Weight.

TABLE OF TROY WEIGHT.

Grains.	Pwt.	Ounce.	Pound.
24	1		
480	20	1	
5760	240	12	1

The *pound Troy*, in both the U. S. and Great Britain, is equal to the weight of 22.7944 cub. inches of distilled water—barometer 30″. Pound equivalent.

It is used in weighing precious metals.

Apothecaries Weight.

TABLE OF APOTHECARIES WEIGHT.

Grains.	Scruple.	Dracm.	Ounce.	Pound.
20	1			
60	3	1		
480	24	8	1	
5760	288	96	12	1

The *apothecary pound* is the same as that in Troy weight, the only difference in the table being in the subdivisions of the unit. Pound equivalent.

French System of Weights

FRENCH EQUIVALENTS OF WEIGHTS.

Names.	No. of *Grammes.*	Weight of what quantity of water at max. density.	Equivalents in Avoirdupois weight.
Milligramme.	.001	1 cub. millimetre.	.01543316 grains.
Centigramme.	.01	10 " "	.1543316 "
Decigramme.	.1	0.1 " centimetre.	1.543316 "
Gramme.	1.	1.0 " "	15.43316 "
Deca *gramme.*	10.	10. " "	.02204737 pounds.
Hecto "	100.	1 decilitre.	.2204737 "
Kilo "	1000.	1 litre.	2.204737 "
Myria "	10,000.	10 litre.	22.04737 "
Qunital "	100,000.	1 hectolitre.	220.4737 "
Millier or Tonneau.	1,000,000.	1 cub. metre.	2204.737 "

Spanish Weights.

The legal *unit* is the libra of Castile=1.0143 lbs. Avoirdupois. =460 grammes.

TABLE OF SPANISH WEIGHTS.

Granos.	Tomines.	Adarmes.	Ochavas.	Onzas.	Marcos.	Libras.	Arrobas.	Quintals.	Toneluda.	U.S. Ounces Avoirdupois.
12	1									0.0211
36	3	1								0.0634
72	6	2	1							0.1268
576	48	16	8	1						1.0143
4608	384	128	64	8	1					8.1144
9216	768	256	128	16	2	1				16.2288
220400	19200	6400	3200	400	50	25	1			15.3575 lbs.
881600	76800	25600	12800	1600	200	100	4	1		61.4280 "
17632000	1536000	512000	256000	32000	4000	2000	80	20	1	1228.56 "

Divisions of Time.

Seconds.	Minutes.	Hours.	Days.	Weeks.	Julian Years.
60	1				
3600	60	1			
86400	1440	24	1		
604800	10080	168	7	1	
31557600	525960	8766	365¼	52$\frac{5}{28}$	1

Gregorian year.

The Mean Solar or Gregorian year is the interval between two successive passages of the sun over the Vernal equinox, and is=365d, 5h, 48m, 49.7sec.=the Civil Year=365.242218 days. The Gregorian Year was instituted by Pope Gregory XIII in 1582, and is now the *Civil or Legal* year. It contains 365 days for 3 successive years, and on the 4th, 366, *excepting on those centennial* years whose number cannot be exactly divided by 400. Thus the error is only 1 day in 3866 years. The Julian year contains 365¼ days, which is too great by 11m., 10$\frac{3}{10}$ seconds, or 1 day in 120 years.

Julian year.

Common year.

The *Common year* extends through 365 days from midnight December 31, excepting on a *leap* or *bissextile* year, when there are 366 days.

Leap year.

A leap year is one whose number is divisible by 4, except those divisible by 100 but *not* by 400. *e:g*: 1800.

Siderial year.

A siderial year is the interval between two successive arrivals of the earth at the same point of the celestial sphere. The 1st point of Aries is usually taken.

A month.

A month is the interval of one lunation or 29 ds., 12 hs., 44 m., 2.84 sec., or nearly 29½ days, and is called a *lunar month*, but for business purposes the calendar months of 28, 29, 30 and 31 days are sanctioned by custom.

A *working day* for government employees consists of eight hours.* With engineers and farmers it is frequently from sunrise until sunset. A working day.

—Revised Statutes, § 3738. June 28, 1868. Eight hours shall constitute a day's work for all laborers, workmen and mechanics who may be employed by or on behalf of the Government of the U. S. U.S. "8 hour law."

Fourteen days=one "*fortnight.*" Fortnight.
Ten years=1 *decade.*

Miscellaneous Table.

12 units=1 doz.	3¾ cub. ft.=3 bush. (struck)=1 barrel.
12 dozen=1 gross.	14 lbs. of metal=1 stone.
12 gross=1 great gross.	21½ stones=1 pig.
20 units=1 score.	8 pigs=1 fother.
24 sheets of paper=1 quire.	18 inches=1 cubit.
20 quires=1 ream.	30 degs.=1 Sign of the Zodiac.
2 reams=1 bundle.	12 Signs=The circle of the Zodiac.
5 bundles=1 bale.	90 degrees=1 quadrant.
25 lbs. of powder=1 keg.	60 degrees=1 sextant.
300 lbs. cement=1 barrel.	
100 lbs.=1 quintal.	

A sheet of "medium paper" 24x38 doubled once forms a *folio;* doubled twice, making four leaves, a *quarto;* doubled thrice, making eight leaves, an *octavo;* folded into twelve leaves, a 12mo.; into eighteen leaves, an 18mo.; and into 24 leaves, a 24mo. Book sizes. Folio, &c.

* The Attorney General decides now (1877) that contracts may be made with laborers, and others for ten (10) hours per day, and that if they elect to work (8) hours they are to be paid pro rata.

Section III.

Notes on the Measuring of Artisans' Work and Materials.

Lumber is sold by the *square foot of surface one inch thick* known as *board measure* (*b. m.*). One foot b. m. therefore contains *144 cubic inches*, which is the *unit* of measure.

Lumber

Unit.

If the material be more or less than an inch thick, find its cubic contents in inches and divide by 144. Should any one of the dimensions be expressed in feet divide their product by 12; and any two dimensions expressed in feet multiplied by the third in inches will give the contents in feet b. m.

Rule for calculating contents.

Round timber may be measured either by the number of lineal feet of a given cross-section the stick will square; by the number of cross-ties or fence rails it will make; the number of feet b. m. it will furnish or the amount of cord wood that may be cut from it.

Round timber.

How measured.

All spruce and white pine spar timbers under 11 inches in diameter are called "*inch spars;*" those over it, "*piece spars.*"

Spars, inch and piece.

For the volume of *round timber* take the girth at the middle, and multiply the square of one-fourth of it by the length. If ash or beech, deduct ½ in. from the quarter girth before squaring, for the bark, if any; and from 1 to 2 inches for oak, elm, fir, &c., according to thickness.

To find volume o round timber.

Hewn Timber.

Straight pieces are estimated either by the *running*, superficial or solid foot.

Straight pieces.

Keel pieces by the running foot.

Keel pieces.

Wharf and crib timbers are measured on the face or upper side of the log, and sold by the superficial foot; whilst crooked, curved, and all pieces hewn to a particular shape are sold by the piece. If pur-

Wharf and crib timber.

Irregular pieces and knees.

chased by the government they are all measured by the solid foot, except *knees*, which are bought by the inch; $\frac{3}{5}$ of the smallest girt of the arm in inches is considered the contents of the knee in feet.

Sawed timber=lumber, by the 1000 ft. (per M.) b. m. Sawed timber or lumber.

*Carpenters' and Joiners' Work.**

Includes all the woodwork in buildings, which is usually measured by the square of 100 superficial ft. 100 sq. ft. the *unit.*

Door and window frames, &c., are measured by the lineal foot at prices varying with the nature and amount of the work. Door and window frames.

Partitions are measured superficially by the square, according to actual dimensions. Partitions.

In roofs multiply the girth by the length of the building, both in feet, and reduce the product to squares. Roofs.

Doors and outside shutters are estimated by the square foot and the prices regulated according to thickness, number of panels and finish. Doors and shutters.

Mouldings and *architraves*, &c., are estimated for by the lineal foot at prices varying according to the width and thickness. Mouldings.

Sash are measured by the *light*, according to the size of the glass and thickness of sash. Sash.

Weather boarding, by the "square" at prices varying according to the width of the boards. Weather boarding.

Stairs are measured by the lineal foot and the price graded according to the breadth of the stairway from wall to *nosing* and to the number and height of the *risers*. Stairs.

Handrails are so much per lineal foot, depending upon the material, size and finish. Handrails.

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* More than a century ago the Carpenters' Company, of Philadelphia adopted a scale of prices and system of measuring which has been the basis of all their measurements to the present time. Every detail of a building was carefully analyzed and the price fixed by the quantity of material and amount and kind of labor and finish. To adjust this list to the numerous changes produced by the introduction of wood working and other machinery the estimate is made by actual measurement on the original basis, and a percentage, previously agreed upon, is then deducted. The code is contained in a large volume which is a *lettre de cachet* to all but the master builders, who are members of the Society.

Excavators' Work.

Excavators' work is estimated by the *cubic yard*, usually *in situ*, and the limits of the *lead* or haul should be stated. Beyond a certain stipulated length of lead the material is paid for both as excavation and embankment, or an allowance made for each additional 100 ft. of haul.

Excavations, by the cubic yard.

For long hauls.

Trenches, for the *bed of a foundation* are measured separate from the general excavation.

Trenches.

In dredging it is customary to measure the sand, mud, gravel, &c., in the dump scow by the displacement due to the load. For this purpose gauges are attached by an inspector who notes the effects of various weights placed in the scow by the contractor, and at his expense. The cubic contents of the scow may also be taken as the measure.

Dredging.

Rock is computed by the cubic yard.

Rock work.

Clearing and grubbing by the acre; large stumps and snags by the piece, according to size.

Clearing and grubbing.

Masons' Work.

Masons generally compute the contents of a wall in *perches* of 22′ ft. All walls less than 16″ thick are considered of that thickness, but if more the excess is charged for. Walls having angles are measured on the outerside, and for the *material* allowance is made for openings; but in computing the *work* the wall is measured as if solid when the openings are less than four feet.

Mason's work in perches.

Measuring for material for work.

Columns or blocks of stone are measured by the solid foot or piece, but chimney pieces, slabs, flags, and other flat work by the square foot.

Columns.

Flat work.

Cut stone masonry and *coping* composed of *dimension stone* is measured before the stones are laid.

Dimension stone.

Concrete and *rubble* are usually measured after being placed in position.

Concrete and rubble.

Curb stone is measured by the lineal foot, and the corner stones by the piece.

Curb stone.

The most reliable unit for mason's work is the cubic yard or the cord.

Best units.

Rules for Measuring Hammered Granite Stone, adopted at Boston, April, 1829.

Preamble.—To prevent misunderstanding between stonecutters, masons, and their employers, in relation to measurement of hammered granite stone, it was deemed expedient that a meeting be called of those engaged in the business, to endeavor to agree upon some uniform system that shall be equally intelligible to all parties; said meeting was held in March last, when a committee of eleven persons was chosen, to take the subject into consideration, and report at a subsequent meeting. At a meeting in April, said committee reported that they had attended to the duty assigned them, and, after mature deliberation, have agreed on the following rules, which, if adopted, will, in their opinion, greatly promote the interest as well as the harmony of all concerned in the business, whether purchaser or vender; at which meeting said rules were adopted by the unanimous vote of all present, who then affixed their signatures to the same, since which others have subscribed their names.

RULES.

Section 1. Ashlar Stones are to be measured on their fronts, quoin-heads, and *reveals* against doors, windows, and recesses.

Section 2. Headers or binders, that make the thickness of the wall, are to be measured as ashlar-work, adding their beds, or builds.

Section 3. Double-headed Quoins, not less than nine inches each head, are to be measured as ashlar-work, adding their beds or builds.

Section 4. Window-caps, for ashlar-work, are to be measured on their fronts, under sides that show, and reveals.

Section 3. Window-sills, for ashlar-work, are to be measured on their tops and fronts, the whole thickness of their rise, and half their under sides.

Section 6. Belt Stones, for ashlar or brick-work, from seven to nine inches rise, and the usual thickness of ashlar-work, are to be cast at the rate of a superficial foot to each foot in length.

Section 7. Arch Stones, in ashlar-work, are to be measured their extreme lengths by their extreme widths, adding the returns and reveals.

Section 8. Ashlar Stones, for pediments or gable ends of buildings, and other similar purposes, are to be measured their extreme lengths by their extreme widths.

Section 9. Plinths are to be measured on all parts that show, and half the rough-hammered parts.

Section 10. Pilasters are to be measured on their fronts, returns, and reveals.

Section 11. Imposts are to be measured on their fronts, ends, and beds, or builds.

Section 12. Posts or Caps are to be measured on four sides, and the ends of caps that show.

Section 13. Posts in or out of square are to be measured on four sides, squaring from their extreme points.

Section 14. Door-sills, under posts, are to be measured on their tops, fronts, and ends, and half the parts hammered under the ends.

Section 15. Window-sills between posts, are to be measured on their tops, under sides, and their whole rise.

Section 16. Arch Caps and Blocks, that make the thickness of the wall, are to be measured on four sides, the extreme lengths by their extreme widths.

Section 17. Belt Stones, that make the thickness of the wall, are to be measured on their fronts, beds, and builds, and ends that show.

Section 18. Courses of Stones, that make the thickness of the wall, are to be measured on their fronts, beds, and builds.

Section 19. Door-steps are to be measured on their tops, fronts, and laps, and the ends that show, which ends are to be measured at the rate of a superficial foot to each foot on the width.

Section 20. Returns for steps, from six to ten inches rise, are to be measured at the rate of a superficial foot to each foot in length.

Section 21. Platform Stones are to be measured as steps; when two or more are required, half the edges for joints are to be added.

Section 22. Spiral Steps are to be measured their extreme length by their extreme width, rise, and laps, and ends that show.

Section 23. Fence Stones are to be measured on their fronts, tops, and inside, where hammered, and ends that show.

Section 24. Posts, that stand in the ground, are to be measured on four sides and tops, and half measurement of the rough parts in the ground, according to the dimensions of the hammered parts.

Section 25. Cellar-door Curbs, are to be measured on their tops and inside, or rise, the whole length of each stone; the rabbits are to be measured the length of each stone by the running foot.

Section 26. Cellar-window Curbs are furnished by the piece.

Section 27. Well Curbs are to be measured on the outside and tops, where hammered with the jogs and corresponding ends.

Section 28. Cesspool Curbs are to be measured as Cellar-door Curbs.

Section 29. Gutter Stones are to be measured on the top side by the superficial foot; cutting gutters to be charged extra.

Section 30. Edge Stones are to be measured by the running foot, double measure when circular.

Section 31. Cutting Scrolls, Jogs, Rabbets, Grooves, Gutters, and Drilling Holes are extra work, and do not add to or diminish from the measurement of the work.

Section 32. Vault Stones are to be measured on three or four sides, as may be hammered, and the ends that show. Floor and Ceiling stones, more than nine inches in thickness, are to be measured on one side and two edges, and the ends that show; when nine inches or less thickness, on one side and the ends that show.

Section 33. All Stones not included in the foregoing specifications, on account of their irregular form or unfrequent use, should be measured as nearly as possible according to the rules applying to those which resemble them.

Section 34. Those which differ in all respects must be furnished by the piece.

Section 35. The two foregoing observations apply to Ornamental Work, the parts of which are so minute, and generally of such complicated forms, that no system of rules sufficiently short and comprehensive can with any utility be adopted; with regard, however, to two or three parts of Ornamental Work, in common use, it may be well to state, that Cornice is usually furnished by the running foot; Bases, Columns, and Capitals, by the piece.

Section 36. All Circular Work to be charged extra, and the mode of measurement should be agreed upon at the time said work is contracted for.

Bricklayers' Work.

Variable units in use.

Bricklayers' work is often measured by the rod, applied only to the surface, the price being regulated by the thickness. But the dimension of the rod being variable, as that of $16\frac{1}{2}$ feet square=$272\frac{1}{4}$ sq. ft.; that of 18 ft. sq. or 324 sq. ft.; that of $16\frac{1}{2}$ sq. ft. and that of 63 sq. ft., it is better to adopt the other systems of measuring *by the thousand* or by the cubic foot or yard.

Standard by the thousand.

Dimensions of bricks.

The dimensions of bricks vary slightly, but a cubic foot is assumed to contain twenty bricks $8\frac{1}{2}'' \times 4'' \times 2\frac{1}{2}$; a cubic yard, 600; and a perch of 22 feet, 500 in the wall.

When brickwork is done by the rod it should be reduced to the standard thickness of a brick and a half or "13 inches."

To find the number of bricks in any wall.

To find the number of bricks required for a wall of given dimensions allow $\frac{1}{10}$ of the volume for mortar and deduct all apertures for doors and windows.

Tunnels and arches.

Brick work in tunnels and arches is usually measured by the cubic yard or perch of 25 feet.

Number of bricks to certain volumes.

It is customary to estimate the number of bricks in a wall by allowing a certain number, for each superficial foot, varying with the thickness; thus a 4'' inch wall

contains 7 bricks per sq. ft.; a 9 inch wall contains 14 bricks per sq. ft.; a 13 inch wall contains 21 bricks per sq. ft., &c, increasing by multiples of seven. A square foot of paving takes about 5 bricks.

Plastering.

Plastering on the *flat* is usually measured by the square yard, sometimes by the "square" of 100 sq. ft. It is of two kinds, that on laths known as *ceiling*, and that on walls, as *rendering*. **Unit for plastering is the square yard.** **Ceiling and rendering.**

Cornices, mouldings, &c., are estimated by linear measure, and an additional foot is added for each mitre. When more than 12 inches in girt, the square foot is taken as the unit. **Cornices, &c., when more than 1 ft. wide.**

Deduction is made for doors and windows. **Deduction.**

One cent extra is usually allowed for each lineal foot of corners, and chimney breasts which project less than 9 inches are assumed to be of that width in measuring. **Extras.**

Whitening, coloring or kalsomining are measured in the same way as plastering. **Coloring.**

Painting.

Painters' work is computed in square yards. **Unit=a sq. yd.**

Every part is measured where the color lies, and the measuring line is forced into all the mouldings and corners. It is sometimes computed by the number of pounds of paint consumed. **How measured.**

Double measure is allowed for carved mouldings. **Allowances.**

Windows, sash frames, sky lights, &c., are done by the piece. **Piece work.**

For balustrades take the length of the hand-rail for one dimension, and twice the height of the balusters upon the landing plus the girth of the hand-rail for the other. **Balusters.**

In trellis or lattice work double the area of one side is often taken as the measure of both. **Trellis work.**

Glazing.

Glaziers compute their work by the square foot, in which case the sash is included, or by the light. Glazing by the sq. foot. or light.

For circular and oval windows take the extreme dimensions, and their product will be the area as computed. Circular and oval windows.

Roofing.

Slaters and tilers compute the contents of their work by multiplying the length of the ridge by the girth or "girt" from eave to eave. Area of roofs.

In taking the girt for slating the line must be extended under the eaves until it meets the wall, but for tiling it is only brought to the eaves. To take the girt for slating; for tiling.

Double measure is allowed for hips, valleys, gutters, &c., and no deductions are made for chimneys, skylights, &c., unless expressly stipulated. Extras.

The area may be expressed in sq. yds. or squares. Sq. yds.=unit.

Plumbing.

Plumbers' work is estimated by the pound or hundredweight (the number of lbs. being expressed.) The lb.=unit.

Paving.

Pavers' work is done by the square yard. The sq. yd.=unit.

SECTION IV.

Specific Gravities.

The Specific Gravity of a body is the ratio of its weight to that of an equivalent volume of distilled water at its maximum density and a barometric pressure of 30 inches.

Specific Gravity defined.

If, therefore, the weight of a cubic foot of water, which is 1000 ounces, be denoted by w, and that of an equal volume of the body by W, the specific gravity ($\overline{S.\ G.}$) of the latter will be $=\frac{W}{w}$ From this equation we have $W=w\ \overline{S.\ G.}$, or the *weight* of a *cubic foot* of any body expressed in ounces, is therefore 1000 times its specific gravity; also if the weight of a cubic foot be known in ounces, the specific gravity is found by dividing by 1000.

Formula, to find the weight, knowing the Specific Gravity and *vice versa*.

It is only necessary, therefore, to find the weight of a volume of water equal to that of the substance whose specific gravity is to be determined. This is done by finding the weight (W) of the body in air and also (W′) its weight in distilled water; the loss (W—W′) will be the weight of the displaced equal volume of water or w'. Then the weight in air or W divided by w' will be the specific gravity as before.

General rule.

As some bodies are lighter than water, or soluble in it, it is necessary, frequently, to employ an auxiliary solid whose weights both in air and water are known. This is attached to the lighter body and the compound weighed in air and water. Find the loss in weight of the light body by subtracting that of the heavy body from that of the compound, then divide the weight of the light body in air by this difference for its specific gravity.

To find the specific gravity of a body lighter than water.

The specific gravities of two bodies vary as the weights of equal volumes, for $\overline{S\ G}=\frac{W}{w}$ and $\overline{S'G'}=\frac{W'}{w}$ dividing one by the other we have $\frac{S\ G}{S'G'}=\frac{W}{W'}$ hence to find the

To find the specific gravity of a fluid.

specific gravity of a fluid, weigh a body whose S G is known, both in the air and in the fluid. The loss of weight will be that of an equal volume of the fluid, then as the weight of the body (W) is to the loss (W′), so is the specific gravity of the body to that of the fluid.

The annexed table will be found of value, in connection with the formulæ of Section I, in enabling the engineer to compute the weight or volume of various substances. It is arranged alphabetically and compiled from numerous authorities,* that it may be as complete as possible. The weights are computed from the specific gravity by multiplying by 1000 and dividing by 16 to reduce to pounds.

* Chiefly Brande, Jos. P. Cook, Haswell, Hurst, Molesworth, Spon and Trautwine.

ALPHABETICAL TABLE

OF

WEIGHTS AND SPECIFIC GRAVITIES.

A	Sp. Gr.	Weight of a cub. ft. in lbs.
Acacia wood	.750	46 5
Acetone	.792	49.4
Acid, acetic, monohydrated	1.068	66.37
" " greatest density	1.079	67.3
" arsenic	3 391	212.
" arsenious	3.782	233.
" benzoic	.667	41.7
" boracic, crystalized	1.479	92.44
" " fused	1.803	112.7
" carbonic	.00197	.123
" chlorohydric, concentrated liquid	1.208	75.5
" citric	1.034	64.67
" cyanohydric	.696	43.5
" formic	1.116	70.
" fluoric	1.060	66.25
" hydrocloric, (muriatic)	1.200	75.00
" hyponitric	1.451	90.7
" hyposulphuric, most concen.	1.347	84.2
" molybdic	3.460	216.25
" nitric, fuming	1.451	90 7
" " of commerce	1.220	76.25
" " tetrahydrated	1.420	88.75
" oleic	.898	56.125
" phosphoric, liquid	1.558	97.37
" " solid	2.800	175.
" silicic, quartz	2.653	165.6
" " agate	2.615	163.1
" " opal sil. hydrate	2.250	140.6
" sulphuric, most concentra'd.	1.841	115.0
" sulphurous	2.210	138.1
" tannic	......	......
" tartaric	......	......
" telluric	......	......
" tellurous	......	......
Agate	2.615	163.4
Air	.001205	.075
Alabaster	2.700	168.75
Alcohol, absolute 60°	.792	49.5
" greatest density	.927	58.0
" of commerce	.834	52.1
" proof spirit	.916	57.25
Aldehyde	.790	49.4
Alder wood	.800	50.
Alum	1.714	107.1
Alumina, { corundum, sapphire, ruby, }	4.160	260.0
" emery	3.900	243.75
Aluminate of magnesia, (spinel)	3.700	231.25
" of zinc	4.700	293.75
Aluminium	2.600	162.5
Amber	1 078	67.37
Ambergris	.866	54.1
Amethyst, common	2.750	172.0

A	Sp. Gr.	Weight of a cub. ft. in lbs.
Amethyst, oriental	3.391	212.0
Amanthus, .313 to 1.000	.657	41.1
Ammonia, aqueous	.857	53.6
Antimony, cast, 6.67-6.75	6.710	419.37
" native	6.670	417.9
Apple wood	.793	49 0
Aqua fortis, double	1.300	81.25
" " single	1.200	75.00
Arragonite	2.900	181.25
Arsenic	5.673	354 6
Asbestos, starry	3.073	192.1
Ash, perfectly dry, average	.752	47.0
" American, white, dry	.610	38.15
Asphaltum, .905 to 1.65	1.277	80.0
Azure, stone	2.850	178.15
B		
Bamboo	.400	25.0
Barytes, Sulphate of 4.—4.558	4.279	267.3
" carbonate of 4.1—4.6	4.350	272.0
Barium	.470	29.4
Basalt 2.421—3.000	2.710	169.4
Bath stone (Oolite)	2.100	131.25
Baytree wood	.822	51.4
Beech " .852—.690	.771	48.2
Beech " perfectly dry	.624	39.0
Beer	1.034	64.62
Beeswax	.965	60.31
Beryl, oriental	3.594	223.4
" occidental	2.723	170.2
Bichloride of mercury	5.420	338.75
Bismuth	9.822	614.0
Bisulphide of mercury	8.124	507.75
" ' tin	4.415	276.0
Birch	.567	354.4
Bitumen, liquid	.848	53.000
Blood, human	1.053	65.875
Blood, crassamentum of	1.245	77 8
Borate of magnesia, boracite	2.500	156.25
Brandy	.924	57.75
Brass (copper and zinc) cast av.	8 100	506.
" cu. 67, zinc 33 parts	7.820	488.75
" " 84, tin 16	8.832	552.0
" rolled or plate	8.380	524.0
" wire	8.214	513.4
Brick, pressed	2.400	150.0
" common, 1 367—1.40	1.633	102.1
" fire	2.201	137.6
" work in cement	1.800	112 5
" " in mortar 1.6–2	1.800	112.5
" soft	1.600	100.0
Bromine	3.00	187.5
Bronze, Cu. 8 parts, tin 1, gun metal	8.500	531.25

B	Sp. Gr.	Weight of a cub. ft. in lbs.
Bullet, wood	.928	58.0
Butter	.942	58.875
Butternut wood	.376	23.5
C		
Cadmium	8.690	543.7
Calcite, transparent 2.52–2.73	2.620	163.75
Calcium	1.580	92.5
Campeachy wood	.913	57.00
Camphor	.998	62 4
Caoutchouc (India rubber)	.903	56.4
Carbon, diamond	3.530	220.6
" graphite	3.500	218.75
Carbonate of Baryta	4.300	268.7
" " Iron (iron spar)	3.850	240.6
" " lead (white lead)	6.730	420.6
" " lime, arragonite	2 946	184.1
" " " Iceland spar	2.723	170.2
" " magnesia, giobertite	2.880	180.0
" " manganese	3.550	222.
" " strontia	3.650	228.1
Carnelian (speckled)	2.613	163.3
Cedar, wild	.596	37.25
" Palestine	.613	38.3
" Indian	1.315	82.157
Cement, Am. hydraulic Rosendale, loose	......	60.
Cement, Am. hydraulic, well shaken	......	70.
Cement, Am. hydranlic, thoroughly shaken	......	80.
Cement, a struck bus. loose, 75 lbs.	......	......
" " well shaken, 88 lbs.	......	......
" " packed for sale 100	......	......
" 1 bbl. contains 3 struck bushels, or 3¾ cub. ft. packed	......	......
Cement,	......	......
" Portland } about 110 { av.	1.300	81.25
" Roman } lbs. bush. { av.	1.560	97.25
Chalcedony, common, 2.6–2.65	2.625	164.1
Chalk, 2.752–2.657	2.454	153.4
Charcoal of pine	.441	27.562
" fresh burned	.380	23.75
" of oak	1.573	98.312
" of soft wood	.280	17.50
" triturated	1.380	86.25
Cherry	.715	44.7
" well seasoned	.672	42.0
Chestnut, perfectly dry	.660	41.25
Chromium	5.900	368.75
Chloride of ammonium (sal. ammonia)	1.520	95.0
Chloride of barium	3.900	231.5
" calcium	3.200	200.
" silver	5.548	346.75
" sodium	2.100	131.25
" potassium	1.836	114.75
Chromate of lead	6.600	412.5
" of potash	2.700	168.7
Chrysolite, 2.782–3.400	3.091	193.2
Cider	1.080	67.5
Cinnabar	8.098	506.1
" from Almaden	6.920	432.5
Citron wood	.726	45.4
Clay, dry potters, 1.8–2.1	1.900	119
" " in loose lumps	......	63.
Clay, with gravel	2.480	155.0
Coal, anthracite, 1.436–1.64	1.538	96.1
" a solid yard makes 1¾ yds. when broken for use	......	......

C	Sp. Gr.	Weight of a cub. ft. in lbs.
Coal, cannel, 1.238–1.318	1.278	80.
" caking	1.277	79.8
" bituminous, 1.2–1.5	1.350	84.4
" broken, loose	......	47.-52.
" a heaped bush. 70–78 lbs.	......	......
" a ton occupies from 43–48 cub. ft.	......	......
Cobalt	8.600	537.5
" cast	7.812	488 25
Cocoa, wood	1.040	65.0
Coke	1.000	62.5
" loose, of good coal	......	23.-32.
" National of Va	.746	46.62
" a heaped bush., 35–42 lbs.	......	......
" a ton, 80 to 97 cub. ft.	......	......
Columbium	6.000	375.0
Concrete, mean	2.000	125.0
Copper, cast	8.788	549.25
" rolled	8 95	560.0
" wire	8 88	555.0
Copal	1.045	65.3
Coral, red	2.700	168.75
" white	2.550	160.0
Cork	.240	15.0
Cornelian	2.613	163.3
Corundum	3.710	232.0
Crab tree	.765	47.81
Cypress tree	.644	40.25
" " well seasoned	.441	27.6
D		
Deal wood, Christiana	.689	43.
Deutiodide of mercury	6.320	395.0
Deutoxide of mercury	11.000	687.5
" copper	6.130	383.12
" tin	6.700	418.75
Diamond, oriental colorless	3.521	220.1
" " colored, av.	3.536	221.0
" Brazilian	3.444	215.25
" " colored	3 550	222.0
Dog wood	.756	47.25
Dolomite, 2.54–2.83	2.685	168.0
Dragon's blood (a resin)	1.204	75.25
E		
Earth, dry common loam, loose	1.280	72.-80.
" " soil	2.194	137⅛
" loose dry	1.500	93.75
" " slightly moist	......	70.-76.
" shaken, more "	......	75.-90.
" fluid mud	......	104-112
" moist sand	2.050	128⅛
" mould, fresh	2.050	128⅛
" rammed	1.600	100.
" rough sand	1.920	120.
" with gravel	2.020	126¼
Ebony, American	1.331	86⅙
" Indian	1.209	75½
Egg	1.090	68.0
Elker wood	.695	43.4
Elm, perfectly dry	.570	35.6
Elm	.671	42.0
Emerald	2.680	167.5
Emery	4.000	250.
Ether, acetic	0.868	54.1
" chlorohydric	.874	54.6
" muriatic	.729	45.6
" nitric	.908	56.75
" sulphuric	.715	44.7

F	Sp. Gr.	Weight of a cub. ft. in lbs.
Fat of beef	.923	57.68
" hogs	.936	58.5
" mutton	.923	57.68
Feldspar, 2.438–2.700	2.569	160.6
Fllbert wood	.600	37.5
Fir, Norway	.512	32.0
Firestone	1.80	112.0
Flint, black	2.582	161.37
" white	2.504	156.5
Fluoride of calcium (fluor spar)	3.200	200.
Fluorine	1.320	82.5
Fusel oil	.808	50.5
G		
Gamboge	1.222	76.5
Garnet, precious, 4.–4.23	4.115	257 2
" common, 3.576-4	3.288	205.5
Glass, 2.50–3.45	2.975	186.0
" bottle	2.732	170.75
" common window, crown	2.520	157.5
" thick flooring	2.530	158.1
" green	2.642	165.1
" flint, 2.76–3.00	2.880	180.0
" optical	3.450	215.6
" white	2.892	180.75
Gneiss, common, 2.62-2.76	2.690	168.
" in loose piles	......	96.
" hornblendic	2.8	175.
Granite, Egyptian red	2.654	165 9
" Patapsco	2.640	165.
" Old Dominion, Va.	2.630	164.4
" Quincy	2.652	165.75
" Scotch	2.625	164.06
" Susquehanna, Pt. Deposit	2.704	169.00
Gravel, about equal to sand	1.749	109.31
Greenstone, (trap) 2.8-3.2	3.00	187.
" in loose piles	......	107.
Grindstone	2.143	133.94
Gold, cast pure, 24 carat	19.258	1204.
" native pure	19.32	1206.
" hammered pure, 19.4–19.6	19.50	1217.
" 22 carat	17.486	1093.0
" 20 "	15.709	982.0
Gum Arabic	1.452	90.75
Gum tree, blue	.843	52.69
" water	1.000	62.5
Gunpowder loose	.900	56.25
" shaken	1.000	62.5
" solid { 1.550 1.800 }	1.675	104.7
Gutta percha	.980	61.1
Gypsum (plaster of Paris) av.	2.305	144.
" in lumps	......	82.
" ground, loose (st. bush. 70 lbs.)	......	56.
Gypsum, ground, well shaken, 80 lbs	......	64.
Gypsum, ground, thoroughly shaken, 90 lbs	......	72.
H		
Hackmatack wood	.592	37.00
Hazel "	.860	53.75
Hawthorn "	.910	56.87
Heliotrope (bloodstone) { 2.629 2.700 }	2.664	166.5
Hemlock	.368	23.0
Hickory, pig nut	.792	49.5
" shell bark	.690	43.12

H	Sp. Gr.	Weight of a cub. ft. in lbs.
Hickory, red	.838	52.375
Holly	.760	47.5
Hone, white	2.876	179.75
Honey	1.450	90.62
Honeystone or Mellite	1.620	101.25
Horn	1.689	105.56
Hornbeam, wood	.760	47.0
Hornblende	3.540	221.25
" black, 3.1–3.4	3.25	203.00
Hornstone, 2.533-2.810	2.671	167.0
Hyacinth, 4–4.78	4.390	273.1
Hydrogen gas	.000089	.0056
I		
Ice at 32° F.	.920	57.5
India rubber	.903	56.437
Indigo	1.009	63.06
Iodide of potassium	3.000	187.5
" silver	5.614	350.9
" lead	6 100	381.25
Iodine	4.948	309.25
Iridium, cast by electric battery	18.680	1167.5
" hammered	23.000	1437.5
Iron, cast, 6.9-7.4	7.15	446.
" at 450 lbs. to the foot, 8601.6 cub. in. will make a ton	......	......
Iron, wrought, 7.6–7.9	7.77	485.
" magnetic oxide	5.400	337.5
" cast, gun metal	7.308	456.7
" hot blast	7.065	441.6
" cold blast	7.218	451.1
" wire	7.774	486.0
" rolled plates	7.704	481.15
" large rolled bars	7.69	480.
Ironstone, 3.28–3.57	3.475	217.2
Iron wood	1.15	71.
Isinglass	1.111	69.437
Ivory	1.825	114.062
J		
Jackwood	.670	42.0
Jasmine	.770	48.125
Jasper, 2.358–2.816	2.587	161.7
Jet	1.300	81.25
Juniper	0.566	35.37
L		
Lance wood	.720	45.
Larch " 5.44–5.60	.552	34.5
Lard	.947	59.2
Lead, cast	11.352	709.5
" rolled	11.388	712.0
Lemon tree	.703	43.94
Lignum-vitæ	1.333	83.31
Lime wood	.804	50.25
Lime, ordinary quick	.843	52.7
" hydraulic	2.745	171.5
" ground, loose, st. bush. 71 lb	......	57.
" " well shaken, 80 "	......	64.
" " thoroughly 93¾ "	......	75.
Limestones & marbles, 2.85-2.65	2.75	172.
" one cub. yd. solid makes about 1.9 yds. loose, or 1¾ yds. piled when .571 is solid and .429 voids	......	......
Linden wood	.604	37.74
Lithium	.590	45.5
Locust wood	.728	45.50
Logwood	.913	57.06

M	Sp. Gr.	Weight of a cub. ft. in lbs.
Magnesia, carbonate of	2.400	150.0
" native hydrate of	2.330	145.6
Magnetic oxide of iron	5.400	337.5
Mahogany, .72-1.063	.892	55.75
" Honduras	.560	35.
" Spanish	.852	53.25
Malachite, compact	3.790	237.0
Manganese	8.000	500.0
Maple wood	.750	46.87
" bird's eye	.576	36.
Marble, Adelaide	2.715	169.68
" African	2.708	169.25
" Biscayan, black	2.695	168.43
" Carara	2.716	169.75
" common	2.689	167.87
" Egyptian	2.668	166.75
" French	2.649	165.56
" Italian, white	2.708	169.25
" Parian	2.838	177.37
" Vermont, white	2.65	165.57
Marl, mean	1.75	109.37
Masonry, of granite or limestone	......	165.
" of well scabbled rubble, 1-5 mortar	......	154.
Masonry, of granite, dry rubble	......	138.
" roughly scabbled rubble ¼-⅓ mortar	......	150.
Masonry, roughly scabbled, dry	......	125.
" at 155 lbs. per cub. ft., a cub. yd. weighs 1.868 tons, and 14.45 cub. ft.=1 T.	......	......
Masonry of sandstone about ⅛ less than the above	......	......
Masonry of brickwork, pressed, fine joints	......	140.
Masonry of brickwork, medium	......	125.
" " coarse, soft bricks	......	100.
Masonry at 125 lbs. per cub. ft., a cub. yd. weighs 1.507 tons and 17.92 cub. ft.=1 ton	......	......
Mastic	1.074	67.125
" wood	.849	53.06
Melanite or black garnet	3.750	234.4
Mercaptan	.804	50.25
Mercury at 0°C. or 32° F.	13.598	849.9
" " —40° F.	15.632	977.0
" " +60° F.	13.580	848.75
" " 112° F.	13.37	835.6
Mica, 2.75-3.1	2.93	183.
Millstone	2.484	155.25
Milk	1.030	64.4
Mineral pitch or asphaltnm, .905-1.650	1.277	80.0
Mineral tallow	0.770	48.1
Molybdenum	8 600	537 5
Molybdate of lead	6.700	418.75
Mortar, hardened, 1.4-1.9	1.65	103.
Mud, dry close	......	80-110
" wet, moderately pressed	......	110-130
" " fluid	......	104-120
Mulberry wood	.561	35.06
" Spanish	.897	56.06
Myrrh	1.360	85.
N		
Naptha	.848	52.9
Nickel	8 666	541.6
" cast	8.279	517.3
Nitrate of baryta	3.185	199.1

N	Sp. Gr.	Weight of a cub. ft. in lbs.
Nitrate of lead	4.400	277.5
" potash	1.930	120.6
" strontia	2.890	180.6
Nitre	1.900	118.75
Nitrogen (about 1-35 lighter than air)	......	......
O		
Oak, African	.823	51.437
" Canadian	.872	54.5
" Dantzic	.759	47.43
" English	.932	58.25
" green	1.146	71.625
" heart (60 years old)	1.17	73.125
" live, green	1.26	78.75
" " seasoned	1 068	66.75
" white, dry	.860	53.75
" red, black, &c	......	32-45
Obsidian	2.359	128.7
Oil of amber	.868	54.25
" aniseseed	.986	61.625
" sweet almonds	.932	58.25
" bitter "	1.043	65.2
" carraway seed	.904	56.5
" cinnamon	1.010	63.1
" citron	.847	53.0
" cloves	1.036	64.7
" codfish	.923	57.6
" cotton seed	......	......
" cumin	.969	60.6
" hempseed	.926	57.9
" lavender	.894	56.
" linseed	.940	58.75
" naptha	.848	53.0
" olive	.915	57.18
" palm	.969	60.56
" petroleum	.878	54.875
" poppy seed	.939	58 7
" rape seed	.914	57.12
" sun flower	.926	57.875
" spirea	1.173	73.3
" turpentine	.870	54.37
" whale	.923	57 68
" wormwood	.907	56.7
Olefiant gas	.00127	.079
Olive wood	.923	87.6
Oolites or roestones, 1.9-2.5	2.200	137.0
Opal, precious	2.114	132.1
" common	2.04	127.5
Opium	1.336	83.5
Orange wood	.705	44.06
Orpiment, 3.048-3.5	3.274	204.6
Osmium	10.000	625.0
Oyster shell	2.092	130.75
Oxide of bismuth......9	8.968	560.5
" silver	7.250	453 1
" zinc	5.600	350.0
Oxygen gas (1-10 heavier than air)	.00143	.089
P		
Palladium	11.300	706.2
" rolled	11.800	737.5
Paving stones	2.416	151.0
Pear wood	.661	41.31
Pearl, oriental, 2-51-2.75	2.630	164.4
Pearl, stone	2.340	146.2
Peat, dry unpressed	......	20-30
Peroxide of iron	5.225	326.6
" lead	9.200	575.0

P	Sp. Gr.	Weight of a cub. ft. in lbs.
Peroxide of manganese	4.480	280.0
" titanium, rutile	4.250	265.6
Persimmon wood	.710	44.375
Peruvian bark	.784	49.0
Petroleum	.878	54.875
Phosphorus	1.770	110.6
Pine, Dantzic	.649	40.
" Memel	.550	34.3
" Riga	.466	29.0
" white, perfectly dry	.400	25.0
" " 1000 ft. b. m., weighs .930 ton	......	......
Pine, yellow Northern, .48-.62	.550	34.3
" 1000 ft. b. m. weighs 1.276 T.	......	......
" yellow, Southern, .64-.80	.720	45.0
" " " heart, unseasoned	1.04	65.0
Pine, pitch	1.150	71.7
Pitch	1.150	71.9
Pitchstone, 1.92-2.72	2.345	146.6
Plaster of Paris	1.176	73.5
Platinum	21.530	1342.
" wire	21.042	1315 1
" rolled	22.060	1379.
" in grains, native	17.500	1094.
" forged	20.336	1271.
Plum wood	.785	49.06
Plumbago or graphite	2.200	137.5
Pomegranate	1.351	84.62
Poon wood	.580	36.25
Poplar	.383	23 9
" white	.529	33.06
Porcelain, China	2.300	143.75
" Sevres	2.145	134.1
Porphyry, red	2.765	172.8
" Seltzer	1.003	62.7
Potassium at 59° F	.865	54.1
Powder, slightly shaken	1.000	62.5
Proof spirit	.916	56.0
Protoxide of antimony	5.778	361.0
" copper	5.300	331.2
" lead, cast	9.500	593.7
Protohcloride of mercury	7.140	446.
Protoioide " "	7.750	484 4
Protosulphide of tin	5 267	329.2
" manganese	3.950	247.0
" copper	5.690	355.6
Pummice stone, .792-.914	.883	55.2
Q		
Quartz, common pure	2.65	165.0
" finely pulverized, loose	......	90.
" " " well shaken	......	105.
" " " packed	......	112.
" quarried loose, 1 part solid, makes 1⅙ loose	......	......
Quince wood	.705	44.06
R		
Realgar, 3.225-3.38	3.278	204,7
Red lead	8.940	558.7
Red oxide of manganese	4.722	295.1
Resin or rosin	1.089	68.1
Rhodium	10.650	665.6
Rock crystal	2.735	171.0
Rosewood	.728	45.5
Rotten stone	1.981	123.8
Ruby	4.04	252.5
Ruthenium	8.600	537.5

S	Sp. Gr.	Weight of a cub. ft. in lbs.
Salt	2.07	129.4
Saltpetre	2.090	130.62
Sand, pure quartz, dry and loose	1.65	90-106
" struck bushel, 112-133 lbs.	......	......
" average 98 lbs. per cub. ft.	......	......
" a struck bush.=122½ lbs and 18.29 bush.=1 ton. A cub. yd.=1.181 tons, and 22.86 ft.=1 ton	......	......
Sand, well shaken, st. bush. 123-147 lbs.	......	99-117
Sand, well packed	......	101-119
" perfectly wet, drained off	......	120-140
Sandstones, for building, dry, 2.10-2.73	2 41	150.
Sandstones, piled, 1 measure solid =1¾	......	86
Sapphire	3.994	237.1
" oriental	4.100	256.2
Sardonyx	2.615	163.4
Sassafras wood	.482	30.122
Satin wood	.885	55.315
Scammony of Smyrna	1.274	79.6
Schorl	3.170	198.1
Sea water	1.026	64.1
Selenium	4.400	275.
Selenite of lead	7.690	480.6
Serpentine, 2.264-3.00	2.634	164.6
Sesquioxide of manganese	4.810	306.2
Shale, red or black	2.600	162.5
Shingle, (pebbles and sand)	1.420	88.7
Silicate of zirconia	......	......
Silver, pure cast	10.474	654.6
" hammered	10.511	686.9
" glance, 5.2-7.2	6.25	390.6
Slate, 2.672-2.90	2.791	173.2
" purple	2.784	174.
" drawing	2.110	132.
Smalt	2.440	152.
Snow, freshly fallen	......	5 to 12
" compacted by rain	......	15-20
Soapstone or steatite, 2 65-280	2.73	170.
Soap	1.071	66 9
Sodium at 59° F	.972	60.75
Spar, fluor 3.094:3.791	3.442	215.1
" feld	2.700	168.75
" calc, 2.62-2.837	2.729	170.6
Spelter or zinc, 6.8-7.2	7.000	437.5
Spermaceti	.943	58.937
Spruce	.500	31.25
Stalactite. 2.323-2.546	2.434	152.1
Starch	.950	59.37
Steam	.0088	.055
Steel, 7.8 to 7.9	7.85	490.0
" plates	7.806	488.
" soft	7.833	489.6
" tempered and hardened	7.818	488.6
" wire	7.847	490.4
Stone, Bath, Eng.	1.961	122.56
" Blue Hill	2.640	165.
" Bluestone (basalt)	2.625	164.
" Breakneck, N.Y.	2.704	169.
" Bristol, Eng	2.510	156.8
" Caen, Normandy	2.076	129.75
" common	2.520	157.5
" Craigleth, Eng.	2.316	144.75
" grind	2.142	134.0
" Kentish rag	2.651	165.6
" Kips bay, N. Y	2.759	172.
" Norfolk, Parliament house	2.304	144.
" Portland, Eng	2.368	148.

* See Gen. Q. A. Gillmore's Report on the Strength and Specific Gravity of Building Stones.

S	Sp. Gr.	Weight of a cub. ft. in lbs.
Stone, rotten	1.981	123.8
" sandstone (mean)	2.400	150.0
" Sydney	2.237	139.8
" Staten Id., N.Y.	2.976	186.
" Sullivan Co.	2.688	168.
Strontium	2.540	158.7
Sugar	1.606	100.4
Sulphate of Baryta, (heavy spar)	4.700	293.7
" strontia (celestine)	3.950	247.0
" lead	6.300	393.7
" silver	5.340	333.7
" lime (anhydrite	2.900	181.2
" " gypsum	2.305	144.0
" potash	2.400	150.0
" soda, anhydrous	2,630	164.4
Sulphide of antimony	4.334	270.9
" bismuth	6 540	408.7
" carbon	1.263	789.4
" lead, galena	7.580	473.7
" molybdenum	4.600	287.5
" silver	7.200	450.0
" zinc (blende)	4.160	260.
Sulphur, native	2.086	130.4
" fused	1.990	124.4
Sycamore wood	.623	39.0
T		
Talc, mean	2.800	175.0
" black	2,900	181.25
Tallow	.940	58.6
Tamarack tree	.383	23.93
Tar	1.00	62.25
Teak, African oak, 6.57-7.45	.701	43.8
Tellurium	6.110	382.0
Thalium	11.850	740.6
Tile	1.815	113.4
Tin, Cornish hammered	7.390	462.0
" " pure	7.291	455.7
Topaz (oriental)	4.011	250.7
Tourmaline	3.210	200.6
Trap	2.720	170.0
Tungsten	17.600	1100.0
Turf, or peat dry and unpressed	......	20-30
Turquoise. 2.50-3.00	2.750	172.0

U	Sp. Gr.	Weight of a cub. ft. in lbs.
Ultramarine	2.360	147.5
Uranium	18.23	114.8
V		
Vine wood	1.327	83.0
Vinegar, 1.013-1.080	1.047	65,5
W		
Walnut wood	.671	41.937
" " black	.500	31.25
Water, pure rain or distilled, at 32°	......	62.37
" " " " 60°	1.000	62.331
" sea	1.026	64.1
" Dead Sea	1.248	78.0
" Meditteranean	1.029	64.3
Wax, bees	.965	60.5
" shoemakers	.897	56.1
Whey, cows	1.019	65.0
White oak, upland	.687	42.9
" James River	.759	47.3
Willow, .585-.486	.535	33.4
Wine, Bordeaux	.993	62.1
" Burgundy	.991	62.0
" white champagne	.997	62.3
" Constance	1.081	67.6
" Madeira	1.038	65.0
" Malaga	1.022	64.0
" Port	.997	62.3
Wolfram	7.119	445.
Woodstone, 2.045-2.675	2.360	147.5
Y		
Yew, Dutch	.788	49.2
" Spanish	.807	50.4
Z		
Zeolite	2.40	150.0
Zircon	4.542	284.0
Zinc, cast	6.861	428.8
" rolled	7.191	449.4

Section V.

The accompanying estimates for one mile of R.R. superstructure, and for an art building, will illustrate briefly the methods of working up and presenting the data contained in this chapter:

*Estimate for one mile of Superstructure for the Cincinnati Southern R. R.**

Iron rail at the present time.	
94.285 tons Iron Rail, @ $52.75,	$4,973 54
360 Joints, @ $1 40	504 00
6000 Spikes, @ $2 85 per C.	171 00
2640 Cross Ties, 8 ft. x 6 ins. x 8 ins. and 10 ins., @ 40 cents,	1,056 00
Ballasting,	1,500 00
Distribution of Material,	250 00
Laying Track	400 00
	$8,854 54
If Steel Rails be used it will require	
83.285 tons, @ $76 75,	$6,392 12
360 Joints, @ 95 cents,	342 00
And for distributing material	230 00
The remaining items being the same as above, give a total of	$10,091 12
The total estimate for cost of track was for	
132 miles Steel Rails, @ $10,091 12,	$1,332,027 84
129 " Iron " including 25 miles of turnouts, @ $8.854.54	$1,027,689 66
Switches and frogs	30,000 00
	$3,389,717 50
From which $30,000 were deducted for old rails, leaving	$3,359,717 50

* From the report of Thos. D. Lovett, Consulting and Principal Eng. Nov. 1, 1875.

REVISED DESIGN

IN COMPETITION FOR PROPOSED

CENTENNIAL EXHIBITION BUILDING,

FOR EXPOSITION OF

INDUSTRY OF ALL NATIONS,

To be held in Philadelphia in 1876.

John McArthur, Jr.,
Joseph M. Wilson, C. E.,
Architects.

LIST OF PLANS TO ACCOMPANY REVISED DESIGN.*

1. South Elevation, Main Building.
2. Plan ot first floor, Main Building.
3. Plan of second floor, Main Building.
4. Plan of basement of Memorial Hall.
5. Section through Memorial Hall.
6. Section through Temporary Building.
7. Block Plan.
8. Supplementary Block Plan.
9. Plan showing Temporary Buildings removed.
10. Perspective of Memorial Building.
11. Interior Perspective of Memorial Hall.

Plans, Elevations, &c., of Preliminary Design.

* These plans are omitted, as the elements of the design are sufficiently manifest from the accompanying description.

TO THE HONORABLE THE COMMITTEE ON PLANS AND ARCHITECTURE, OF THE U. S. CENTENNIAL COMMISSION:

GENTLEMEN:—In presenting our modified preliminary plans of the proposed Centennial Exposition Buildings, for a second and final competition, we respectfully call attention to the following *essential* and consequently *important considerations:*

1st. Our design can be executed without fail between now and 1876.

2d. It admits of the most plain and common sense application of the dual classification.

3d. It is built of the ordinary materials—iron, brick and wood—in every day use in the United States, and they are used according to the latest and most improved methods of construction.

4th. Both the exterior and the interior effects are more imposing than those of any previous Exhibition Building in the world.

5th. The ordinary rolled sections of wrought iron having been used, and the reduplication of parts having been carefully attended to in working up the design, the result is that these superb effects can be obtained at the most reasonable cost.

6th. We confidently believe that the Memorial Hall will be found, when left standing alone after the Exhibition is over, to be a fair representative of the progress which America has made in Engineering and Architecture during the past hundred years. We have made the following modifications in our design:

Modification of original design.

First, we have abandoned altogether the use of galleries for exhibition purposes; and secondly, we have simplified the construction of the temporary portion of the building; omitting the towers and modifying the fronts so as to lessen as far as practicable the cost of this part of the structure, consistent with a creditable appearance, and a proper adaptation to the purposes in view. The space formerly provided in the galleries has been transferred to the first floor, thereby enlarging the plan, and in this respect, perhaps, increasing the expense; but there is no doubt as to its being a decided improvement for exhibition purposes. In order to obtain good views of the scene below, narrow galleries have been placed in the Memorial Hall, and in certain parts of the Temporary Buildings; but they have not been included in what would be denominated the exhibition space of the structure.

The block plan.

The *block plan* shows the general arrangement of the building, and its accessories. The portion tinted carmine represents Memorial Hall; and that tinted India ink, is the temporary part.

GENERAL DESCRIPTION.

The modified design comprises a central, permanent, Memorial Hall, flanked by two equal temporary wings. The Memorial Hall itself forms a complete design, either alone or in connection with the temporary parts.

Memorial Hall.

The Memorial Hall consists of two principal parts crossing each other at right angles, forming a nave with transepts, at the intersection of which, in the centre, rises a tower. This is entirely of skeleton construction, built of wrought iron, and the lower portion open, so as to obstruct the view as little as possible; being formed of sixteen columns, arranged in sets of four each, with those of each set braced vertically and laterally, to resist the heaviest winds. The exterior portion above the roof of the building is covered with galvanized iron on the vertical sides, and slate on the roofs; and at proper intervals in the height, floors are laid to furnish outlooks to visitors; access being had to the same, by convenient stairways and steam elevators. Platforms are intended on the ridges of the main roof, accessible from the tower. These platforms will not be observed from the ground below, and will be found very attractive as promenades. The four main fronts of the building are each designed so as to be finished and complete in themselves, when the temporary structures are removed. The south front, which we consider the main approach, provides on the first floor an ample entrance flanked by waiting rooms, both for ladies and gentlemen, with all appropriate conveniences; also, coat room, telegraph office, and news stand. A portion of the area under the main roof, and not interfering with the classified exhibits, is devoted to restaurant purposes, as also are open corridors or porches on the sides. A basement is intended under this front, divided into kitchens, pantries, rooms for steam boilers, fuel, cellars, &c.; boilers will furnish steam for cooking, for heating the buildings when necessary, and for motive power for elevators. The kitchens connect with restaurants above by dumb waiters. From the first floor, the second floor is reached by wide stairways. It contains a foyer or concert room, retiring rooms, and some smaller rooms which may be used by commissioners, or rented to officials representing the various countries exhibiting. Such rooms will be found very convenient, and can readily be let at remunerative rates. The foyer opens on a gallery next to the interior of the building, which communicates with open corridor restaurants at the sides, and connects with galleries extending around into the transepts, and having stairways in the transept towers to the first floor. The foyer communicates in the front of the building with an open air promenade over the main carriage porch. The north front provides on the first floor, the proper conveniences for visitors entering at this end of the building; and also contains a restaurant within the building, and open corridor restaurants at the side. Wide stairways communicate to a large organ and orchestra

The tower.

Stairways and steam elevators.

South entrance or main approach.

Restaurant.

Kitchens, Pantries, Steam boilers.

Foyer or concert room.

Galleries.

North entrance.

Organ.

or chorus gallery, from which side galleries run the whole length of the nave, and around into the transepts, the same as those from the south front. Under this front is a basement or cellar, that may be used for the same purposes as that under the south front. There is ample water closet accommodation on the first floor of the transept towers. The Memorial Building being intended to be permanent, there are certain features in way of kitchens, cellars, heating apparatus, &c., introduced, not so much on account of being required now, as that they will be needed in the future. Orchestra gallery.

Temporary portion of the building.

The two equal portions of the temporary building connecting with the permanent building at the transepts, may be said to consist each of a nave, with transepts facing north and south. The nave is available directly for exhibition purposes, forming with the transepts of the Memorial Building, a grand space of 2,040 feet long by 360 feet wide. In the transepts are located offices, ample waiting rooms, restaurants, &c., as will more fully appear on examination of the plans. These departments all require provision to be made for them, and we prefer placing them in transepts, distinct as it were from the exhibits, yet convenient to them, thus allowing us to obtain the necessary projections for a fine facade to the elevation, and at the same time fully utilizing all of the space.

Grand space for exhibits, with offices, &c.

Nave and Transepts.

The width of the nave, 360 feet, is made up of a centre span of 120 feet, two spans of 72 feet, and four spans of 24 feet each. Small galleries have been introduced in the transepts and at the ends of the naves, the latter communicating with outside terraces or porticoes, from which fine views can be obtained. The suites of rooms in the second floor of transepts, can be made use of for bureaus of foreign commissions, &c. It will be seen by reference to the cross sections, that ample light has been obtained for the whole building without resort to skylights.

Light.

There are certain portions of the temporary buildings contiguous to the Memorial Hall, and marked *AA*, *BB*, on the block plan, that have been taken in our computations of areas, estimates, &c., as temporary, but which we would recommend to your committee, if possible, to retain as permanent, when the temporary buildings are removed. The open corridors or porches, AA especially, now intended for restaurant purposes, will be found very pleasant adjuncts to the permanent building, and in working up the perspective for this, we have shown them as retained.

Openings and exits.

We would call attention to the great number of openings that we have provided for the reception of goods. The main entrances are all large and commodious, and all of the first story windows open to the floor, in the temporary and permanent building, forming *doors of* 10 *feet width of opening, one occurring on the side of the building every* 24 *feet.* These are all available for the reception of goods, and may be used or not after the exhibition opens, as may be desired. The level of the floor of the building has been assumed at

Levels and grades.

118, and of the ground outside the walls, at 114, which is about the grade of Belmont avenue. This will allow us to cross Belmont avenue with our temporary tracks at grade, and run them into the building 4 feet below the level of the floor. This is the standard height adopted in this country for freight platforms above the rails. It is the most convenient for unloading, as it brings the floor of car level with the platform of building; and joist can easily be introduced and floored over a few days before the exhibition opens, leaving the track below ready for use again when the exhibition is over. We have introduced four tracks through the whole length of the building, and more can be put in if desired.

Railroad communication.

Underneath certain portions of the floor of the temporary buildings, considerable area occurs, and the idea has been suggested of appropriating this to the storage of empty boxes, &c. It would be very useful for this purpose, except on account of the great risk from fire, and for this reason we would not recommend it. Dust is a great trouble to exhibitors, and it is absolutely necessary to adopt the best means of removing this expeditiously and quietly. We know of no better method than that of laying the temporary floors with a narrow space between the boards, into which the dust may fall; the same as adopted in most of the previous exhibitions. This plan is open to the objection of allowing articles, carelessly dropped, to fall through and be lost. If the floors are laid close, the dust accumulates very rapidly, and must be swept up in piles and conveyed away, at considerable trouble, expense, and risk of spreading again over the exhibits. The utmost care might not prevent a match, for instance, from dropping through one of these openings, and the presence of boxes and packing cases below, would increase the risk of fire immensely.

Storage of empty boxes.

Risk from fire.

Removal of dust.

Plan No. 8 shows the system of drainage proposed for the building, to connect with a main sewer on Forty-eighth street. It also shows the arrangement of water supply, fire plugs, and gas pipes.

Drainage.

No previous exhibitions have been artificially lighted, or open at night, on account of the danger from fire. There is no doubt that the receipts would be vastly increased, if such an arrangement were possible. The public in this country are not as well accustomed to day exhibitions as in Europe; and our previous experience in all cases has been, that the evening receipts amount to a large proportion of the total. What we propose is, to light the building by large reflectors, such as are used in our railroad depots, suspended from the roof, and rows of lights along the various iron cornices, where necessary, the gas being ignited by means of electricity, as now in practical use in many places. Gas itself drops no sparks. By such a method of lighting, the burners being far above anything inflammable, the risk of fire would be at a minimum.

Lighting with gas, and night exhibitions.

DIMENSIONS.

The following are the principal dimensions of the building: Dimensions.

Memorial Hall.

Length of nave, exclusive of waiting rooms at ends	720 feet.
Length through transepts	456 "
Span, in clear, of nave and transepts, each	216 "

Temporary Building.

Extreme length of each nave	884 feet.
Length through transepts	700 "
Total width of nave	360 "
" " transepts	312 "
Extreme total length of whole building	2,224 "
Area available for classified exhibition purposes, 734,400 sq. ft.	16.86 acres
Portion of Memorial Hall available for unclassified Exhibition purposes, 67,392 sq. ft	1.55 "
First floor area for restaurants, not including open air corridors, 177,808 sq. ft.	4.08 "
Total first floor area for exhibition and restaurants, without open corridors	22.49 "
Area of open corridors, first floor, 29,400 sq. ft.	0. 6 "
Area for offices, waiting rooms, &c	2. 3 "
Total area first floor	25,39 "
Height of central tower to extreme top of finial	500 feet.
Side of square base of tower	120 "
Height of nave, floor to ridge of roof	148 "

By way of comparison, in order to obtain an idea of the dimensions given above, we would state that the span of the roof of the Memorial Hall, 216 feet, is 16 feet greater than that of the Grand Central Depot in New York City; that the centre span of the nave of the temporary building, viz., 120 feet, is exactly the same as that of the grand nave at Sydenham Crystal Palace, London, and that the width of the square base of tower, 120 feet, is very nearly the same as the outside diameter of the dome on the Capitol at Washington; the height of this tower, 500 feet, being the greatest in the world. Comparison with other buildings.

The extreme height of the dome at Washington is	287 feet 5½ inches.
St. Peter's, at Rome	430 "
Spire of Friburg Cathedral	385 "
Spire of Strasburg	468 "
Spire of St. Stephen's, Vienna	441 "
Spire of Town Hall, Brussels	374 "
Spire of Antwerp Cathedral	406 "

The spires of Cologne Cathedral, when finished, according to the original design, will be 510 feet high, and the height of tower of the new public buildings for the City of Philadelphia, when completed, will be 450 feet. As it regards the height of the nave of the Memorial Hall, which is 148 feet above the floor, we would state that the height of the

Nave at Strasburg is	101	feet.
" Cologne Cathedral,	155	"
" St. Peter's, at Rome,	150	"
" Bourges, France,	117	"
" Chartres,	106	"

We are confident that a far finer and grander effect can be produced by a tower as we have designed it, at much less cost than by a dome. The only *iron* dome of any size in existence, with which comparison can be made, is that at Washington. This dome having the same diameter at base as our tower, and far less height, cost $950,000, exclusive of the base of the old dome which extended from the ground to the height of 68 feet. In estimating for the cost of the tower, we beg to state that we have computed all of the material necessary to resist safely the greatest stresses that can come upon it, and have made our estimate from the number of pounds weight of this material, so that we believe our figures are correct.

* * * * * * *

ESTIMATE IN DETAIL.

In accordance with the request of the Commission, by their circular of October 2d, 1873, we hereby furnish the following itemized statement of the quantities and prices of all the material estimated to be necessary to build the structures according to our design as presented.

In preparing our estimate we have been conscientious, and we feel no doubt but that the Commission can have the buildings constructed for the amounts we have here stated. Our prices and quantities are full, and it is quite probable in working up the finished drawings, that some of the items can be reduced both in amount and price. We have been careful not to under estimate any portion of the work, but have made it a point in every instance to assure ourselves that the figures presented are a maximum.

Memorial Building.

Foundations and Stone Walls.

18,632½ perches masonry, @ $9.00	$167,693 00	
4,000 perches masonry, @ $10,00,	49,000 00	
		$207,693 00

Bricks and Brick Work.

13,264,257 bricks, @ $35.00 per M.	464,249 00
(The price of brick is made to include a large amount of ornamental tile, terra cotta, and stone laid with the brick, that could not be separated in detail, also colored bricks.)	
Carried forward	$671,942 00

Brought forward		$671,942 00
Dressed Stone.		
78,375 cubic feet, @ $3.00,		235,126 00
Wrought and Cast Iron Work.		
4 200,000 lbs. wrought iron roof trusses.		
1,259,250 lbs. wrought iron purlins.		
3,200,000 lbs. wrought iron, main tower.		
300,000 lbs. wrought iron gable ends.		
720,550 lbs. wrought iron, north and south fronts and transept towers.		
9,679,800 lbs. wrought iron, @ 10 c.,	$967,880 00	
Elevators, main tower,	32,000 00	
Stairways, main tower,	86,027 00	
1,720,540 lbs. cast iron, @ 5 c.,	86,027 00	
1,010 feet lineal crest railing on roof, @ $7.00,	7,070 00	
		1,124,877 00
Carpenters' Work and Lumber.		
143,143 feet B. M. purlins, sheathing and flooring in tower, and flooring in galleries, white pine, @ $70,00,	$10,020 00	
807,848 feet B. M. temporary flooring, part hemlock, @ $50.00,	40,392 00	
1,377 piles, hemlock, @ $5.00 each,	6,885 00	
Carpenters' work and lumber in north and south fronts and transept towers,	216,166 00	
		273,463 00
Galvanized Iron Work.		
Tower,	$145,000 00	
Gables,	30,000 00	
264 clerestory windows, @ $60.00 each,	15,840 00	
198 dormer windows, @ $50.00 each,	9,909 00	
66 main windows, @ $120.00 each,	7,920 00	
3.360 feet lineal main cornice, @ $5.00 each,	16,800 00	
Finish in north and south fronts, and transept towers, windows, cornices, roofs, &c.	51,872 00	
		277,332 00
Hardware.		
Hardware,		15,000 00
Plumbing, Gas Fitting and Drainage.		
7,150 feet lineal 4 inch pipe from roof, @ 60 c.,	$4,290 00	
660 feet lineal 3 inch pipe from corridors, @ 50 c.,	330 00	
1,270 feet lineal 12 inch, terra cotta, @ 80 c.,	1,016 00	
3,960 feet lineal 4 inch. terra cotta, @ 20 c.,	792 00	
Carried forward		$2,597,740 00

Brought forward		$2,597,740 00
110 4 inch bends, terra cotta, @ 65 c.,	75 50	
110 4 inch by 12 inch T's, terra cotta, @ $3.00	330 00	
22 3 inch by 12 inch T's, terra cotta, @ $3.00,	66 00	
22 3 inch bends, terra cotta, @ 50 c.,	11 00	
4,200 feet of 12 inch pipe, terra cotta, @ 80 c.,	3,360 00	
45 water closet containers, $14.00,	630 00	
45 water closet basins, @ $5.00,	225 00	
45 6 inch by 8 inch T's, terra cotta, @ $1.75,	78 75	
600 feet of 8 inch pipe, terra cotta, @ 45 c.,	270 00	
45 4lb. lead traps, @ $5.00,	225 00	
225 feet of ⅝ inch lead supply pipe, @ 50 c.,	112 50	
6 ⅝ inch stop and water cocks, @ $2.50,	15 00	
360 feet of 3 inch iron pressure pipe, @ 70 c.,	252 00	
1 3 inch stop cock,	30 00	
350 feet of 2 inch iron pressure pipe, @ 50 c.,	175 00	
6 2 inch stop cocks, @ $10.00,	60 00	
330 feet of 1 inch extra strong lead pipe, @ 80 c.,	264 00	
300 feet of ⅝ inch extra strong lead pipe, @ 60 c.,	180 00	
350 feet of 2 inch lead waste pipe, @ 75 c.,	262 50	
6 marble tops, 8 holes each, @ $75.00,	450 00	
50 wash basins, @ $3.50,	175 00	
50 silver plated basin cocks, @ $6.00,	300 00	
50 silver plated plugs and washers, $2.00,	100 00	
150 feet of ½ inch extra strong lead pipe, @ 50c.,	75 00	
6 ½ inch stop and waste cocks, @ $2.25,	13 50	
4 1 inch stop and waste cocks, @ $3.00,	12 00	
250 feet of 2 inch cast iron pipe, @ 50 c.,	125 00	
50 urinals, wedgewood ware, small pattern, @ $7 00	350 00	
50 urinal cocks, plated, @ $5.00,	250 00	
1,000 feet of 4 inch pipe, terra cotta, @ 20 c.,	200 00	
4 2 inch stop cocks, @ $10,	40 00	
660 feet of 8 inch pipe, terra cotta, @ 45 c.,	297 00	
3500 feet of gas pipe, 6 sizes, @ 20 c.,	700 00	
48 reflectors, @ $50.00,	2,400 00	
Electrical lighting,	5,150 00	
Draining in of water-closets, urinals and basins,	1,387 00	
48 6 light brackets, glass drops, under tower, @ $60.00,	2,880 00	
Incidentals,	5,045 25	
		37,000 00

Slate Roofing.

4,701½ squares slate roofing, @ $12.00,	56,418 00
Carried forward	$2,691,158 00

Brought forward		$2,691,158 00

Galvanized Iron and Tin Roofing.

271,320 square feet galvanized iron roof, No. 22, @ 25 c.,	$67,830 00	
1887 square feet tin roofing, @ 11 c.,	2,170 00	
		70,000 00

Plastering.

24,000 square yards plastering, @ 50 c.,		12,000 00

Painting and Glazing.

English ribbed glass ¼ thick is intended in the nave and transepts, @ 50 c., per square foot set, and first quality American double thick for north and south fronts and transept towers.

100,000 square feet of glass, @ 50 c.,	$50,000 00	
Painting nave, transepts and main tower,	75,000 00	
Painting and glazing north and south fronts, and transept towers,	54,042 00	
		179,042 00

Heating and Cooking Apparatus.

Including 8 boilers 14 feet long, 54 inch diameter, 50 horse power each, and 125,000 feet steam pipe, valves, radiators, &c., complete,		50,000 00
Incidentals,		140,000 00
		$3,142,200 00

QUESTIONS ON THE SECOND CHAPTER.

Page 9. Of what use are preliminary estimates? What are the essential elements of all estimates?

Page 13. What is a standard unit? What are ambiguities and why should they be avoided?

Page 14. How do the U. S. and British measures compare? What is the difference between the standard yards? Give the rule for reducing one to the other. Repeat the table for U. S. linear measure; also the miscellaneous measures.

Page 15. What is the difference between a statute and nautical mile? What is the value of a degree of latitude at the equator and the pole? How is the length of a degree of longitude determined for any latitude? What units are used in measuring land and for line surveys?

Page 16. Give the divisions of the metric system for linear measures and their equivalent values. Which are the road measures? What are the units for surfaces both in the U. S. and France?

Page 17. What are their subdivisions and multiples?

Page 18. What are the units for volumes; how divided? How do Government engineers measure stone, sand, earth, timber, &c.?

Page 19. What is the difference between the mason's and quarryman's perch? How are walls less than 16″ thick to be measured? What are the best units? What are the units of capacity? Give the dimensions of a bushel. What is a *heaped* bushel; a *struck* bushel? State the relations in dry measure; in liquid measure.

Pages 20 and 21. What are the dimensions of a gallon? What are the divisions of the gallon used by apothecaries? Name the French measures of capacity. What are the Spanish units? What is the unit of weight? Give the table.

Pages 22 and 23. How many cubic inches are there in a pound of water? Give the table for Troy weight. Apothecaries' weight. What is the French system of weights?

Page 24. How is time divided? What is the distinction to be made in the several years in use? What is a month?

Page 25. What is a working day? How is the law to be construed?

Page 26. How is lumber sold? Define board measure. How are contents calculated? How is round timber measured? What are inch and piece spars? What allowances are made for bark on round timber? How are straight pieces, keels, wharf and crib timber, &c., measured?

Page 27. Sawed timber is how sold? What is the unit in carpenters' work? Give the rules for measuring the several parts of building as stated in the context.

Page 28. Excavators' work is how measured? What is meant by the *lead?* How are prices adjusted for long hauls? Bed of foundation is how measured? dredging? rock work, clearing and grubbing? What is the unit generally used in mason's work? How are walls measured for material and workmanship? other forms? What are the most definite units?

Page 31. How is bricklayers' work estimated? What is the standard? Give the average dimensions of a brick. When measured by the rod what is the thickness? How is the number of bricks in any wall determined?

Page 32. In plastering how is flat work measured? cornices, mouldings, &c.? What deductions and extras are allowed? How is coloring measured? painting? What allowances are made for piece work, balusters, &c.?

Page 33. How is glazing computed? Roofing is how measured? What extras are allowed? What is the unit? Plumbing? Paving?

Page 34. What is specific gravity? give the formula and general rule. How is the specific gravity of a body lighter than water found? that of a fluid?

Page 42. How many spikes, ties and joints are required per mile on the C. S. R. R.? What are the estimates for one mile of iron and of steel track, laid?

Page 44. What were the six "important considerations" to be provided for in the plans for the Art Building, U. S. Centennial Exhibition?

Pages 45 et seq. How were the original designs modified? Describe the design for Memorial Hall with its appointments and approaches; also the temporary portions.

Pages 47 et seq. What is the standard height for freight platforms? What provision was made for storage? What objection existed? How were the floors to be arranged, and why? What were the arrangements for lighting? Define transept, nave, finial, clerestory, purlins, sheathing, &c. What advantages were claimed by the proposed tower over a dome? What was the estimated cost of the building?

CHAPTER III.

SPECIFICATIONS.

The *Specification* is that *part of the contract* which shows *specifically* all those features that cannot be clearly represented in the drawings; such as *quality and quantity of materials; nature of workmanship* and *manner of executiug* the work, with any *general stipulations* or *instructions* that may be found necessary or desirable. The greatest care should be given to its preparation as it forms the basis of the contractor's offer and is his guide all through the work. Every detail should be clearly and accurately defined and nothing should be omitted, nor left to the imagination. A memorandum tablet should be constantly used during the preparation of the drawings, and every thought or suggestion carefully noted.

Specification defined.

Should be very carefully prepared.

Memorandum should be kept.

These points will be sufficiently exemplified by an examination of the accompanying forms furnished by reliable anthorities.

[*From the U. S. Corps of Engineers.*]

FOR HARBOR AND RIVER IMPROVEMENTS.

SPECIFICATIONS
for the
IMPROVEMENT OF THE HARBOR OF CEDAR KEYS, FLORIDA.

UNITED STATES ENGINEERS' OFFICE,
No. 40 Church Street,
MOBILE, ALABAMA, April 7, 1877.

See pages 209, 219, 251.

Specifications.

The work to be done consists in either widening the channel across the bar at the mouth of the Harbor of Cedar Keys, Florida, about 5 miles south of Cedar Keys; or widening and deepening the channel from the bar to Cedar Keys.

Character, extent and locality of the work.

The uniform depth of water to be attained through this channel is 12 feet

at mean low water, and the work will be continued until the appropriation, Ten Thousand (10,000) Dollars, is exhausted.

Tides.

The ordinary rise of the tide is about $2\frac{1}{2}$ feet.

Character of material and distance of dumping ground.

The material to be excavated is sand and mud, intermixed with shell, (easily removed by an ordinary dredging machine,) and will have to be deposited in not less than 6 feet depth of water, at an average distance not exceeding 3 miles.

Measurement.

The amount of material excavated shall be determined by measurement in the scows or barges in which the material is deposited, whose capacity shall be ascertained by the engineer in charge, or his agents, before the work commences.

Inspectors of Dredges will be appointed by the Engineer in charge, and acting under his instructions, shall determine when the scows or barges contain "full loads."

The decision of said Inspectors as to the amount of material excavated and removed, as well as to its location and deposit shall be final, and without appeal on the part of the contractors.

Method of working.

The precise location of work to be done shall be fixed by the Engineer in charge, or his assistants, plainly marked by stakes or buoys furnished by the contractors, who will also provide a suitable boat and men to set them, and necessary help for sounding, at their own expense, under the direction of the United States Agent in charge.

Contractors will be held responsible for any Government property destroyed by the negligence or carelessness of their employees or agents.

All excavations below the required depth, or beyond the lines of the channel shall be deducted from the amount returned by the Inspectors; such excess to be determined by examinations made by the Engineer or agent in charge at suitable intervals. In the event of a deficiency in depth being found and reported to the contractor, payments shall be suspended until the excavation is carried to the required depth by them.

A. N. DAMRELL,

Capt: Engrs: U. S. A.

The above specifications are accompanied by the advertisement (see page 209) and "instructions to bidders" (page 219.) They do not exhibit the *amount of material* to be removed, but this will be found in the advertisement to be 20,000 cubic yards, so that it must form a necessary part of the papers composing the contract. In the last three paragraphs will be found mentioned some of the precautions necessary to be taken that the work may be effectively done and all fraud prevented.

For a Stone Breakwater.

See pages 209, 219, 251.

SPECIFICATIONS FOR RIP RAP GRANITE FOR THE BREAKWATER AT BLOCK ISLAND, R. I.

Rip-rap granite is required to complete the main breakwater, and build a detached piece about 300 feet long to the northward. It is now carried out to fourteen (14) feet of water at mean low water. Material.

Amount to be expended for granite, about $45,000. Appropriation.

The work will be built with a width on top of twenty-five (25) feet, and side slopes of about forty-five (45) degrees. It is to be carried up to about six (6) feet above mean high water. The stone may be thrown in from the deck of a vessel with an ordinary spar derrick. No stone shall be put in more than fifty feet in advance of the finished portion, and all must be completed to the required height before the work will be accepted. Dimensions.

The granite must be of the best quality as to durability, in blocks averaging not less than one and a half (1½) tons each. No block of less than one-half (½) of a ton will be received. The blocks must be as nearly cubical as practicable, the smallest dimension must in no case be less than one-third (⅓) of the largest. The stone found on Block Island will not answer for this part of the work. Nature of Material.

The breakwater is now so far completed as to give shelter in all storms except those from the northeast, to vessels drawing twelve (12) feet. The inner harbor gives shelter from storms in any direction, and has a depth of seven (7) at mean low water. Information.

The mean rise of the tide is three and one fourth (3¼) feet.

The proper season for doing this work advantageously is between the 1st of April and the 1st of October, the season of long days and pleasant weather. The frequent calms at this period prevent sailing vessels from improving it because of their inability to move. For this reason parties bidding must be prepared to use a steam tug for towing their vessels to and from the work, and this will be required in the contract.

The time of beginning this work is on or before May 1st, 1877, and it must be completed on or before November 30th, 1877. The time.

The monthly rate of progress must from the beginning at least, equal the average rate for the whole period in which it is proposed to do the work. The monthly rate of progress.

The price asked for doing this work must be stated by the ton of 2,240 pounds of stone placed in the work. The price.

The vessels to be used by the contractor will be loaded by weighing stone into them at the quarry and putting draught marks on them for every five (5) tons, from the smallest to the largest load that they will carry. These draught marks will be taken as indicating the load of the vessel, if she is in the same condition as to water in the hold, tackle, &c., as when gauged. The gauging of the vessel will be done by the contractor, Measurement.

under the direction of an inspector appointed by the Engineer in charge, before any stone is delivered. The scales for weighing must be furnished by the contractor.

Any failure to commence work on the day specified, or to prosecute it thereafter at the rate and in the manner required, will be considered to allow the United States to annul any contract made, and declare a forfeiture of all reserved percentage or other dues, or to allow the United States, at the option of the Engineer in charge, to carry on the work at the expense of the other party to the contract, and to render him and his sureties liable for any increase of cost over that proposed and agreed upon. Failure to commence

No transfer of a contract, or of any interest in it made in accordance with bids received under these specifications will be allowed. No transfer.

No member of Congress, officer or agent of the Government, nor any person employed in the public service, will be permitted to have any share in any contract made to do this work. No member of Congress

All work done will be subjected to a rigid inspection by an Inspector appointed by the Government, and all that does not conform to these specifications will be rejected. Inspector

Payments will be made at the end of each month, as the work is accepted, reserving twenty per centum till the whole is completed. Payments.

Proposals and guaranty must be made in duplicate, and none will be considered unless upon blanks furnished from this office attached to this advertisement and specifications. Proposals and guaranty.

Further information may be had by applying in person or by letter to this office, where maps of locality may be seen; but bidders are expected to visit the locality and determine everything themselves, and must include the effect of all contingencies in the proposed price. Further information.

The right to reject any and all bids reserved. Right to reject.

G. K. WARREN,
Maj. Eng'rs. and Bvt. Maj. Gen. U. S. A

Engineer Office, U. S. Army,
Newport, R. I., February 22d, 1877.

For Removing Rock.

SPECIFICATION

FOR REMOVING THE OBSTRUCTIONS IN EAST RIVER AND HELL GATE, NEW YORK.

ARMY BUILDING,
Houston and Green Sts.,
NEW YORK, October 5, 1876.

See pages 210, 219, 251.

The dredging consists of the removal of about 24,000 tons of rock from Hallett's Point Reef. Amount.

Dredging must commence at the outside edge of the reef, and 26 feet mean low water. The excavation must be carried regularly forward in such direction as the Engineer in charge shall from time to time Manner of working

prescribe, so that that depth shall be preserved over all the ground dredged. All stones weighing more than ten tons will be broken at the expense of the Government.

The dredging will be bid for by the ton measured in the scows; capacity of each scow to be determined by the Engineer in charge. Measured.

The rock may be either deposited above high water mark, or at such places upon the river bed as may be selected by the Engineer in charge. Deposited.

In case of any doubt as to the meaning of the specifications, the decision of the Engineer in charge shall be considered the correct one, and shall be final. Arbiter.

No proposals will be considered except those coming from parties proposing to use dredges capable of resisting collisions. Conditions.

Payments will be made monthly on certificate of U. S. Inspector, reserving ten per centum until completion of work. Payments.

The work must be completed by June 30th, 1877. Time of completion.

JOHN NEWTON,

Lieut. Col. Engineers, Bvt. Maj. Gen'l.

For a Breakwater of Crib-Work.

SPECIFICATIONS

FOR THE EXTENSION OF CLEVELAND BREAKWATER.

ENGINEERS' OFFICE U. S. A.
120 Pearl Street,
BUFFALO, N. Y., March 26, 1877.

See pages 210, 219, 251.

The cribs, four in number, will be (50) fifty feet in length and (26) twenty-six feet wide, with a superstructure of (7) feet. They will rest upon a foundation of rubble stones, in fragments varying from (50) fifty to (150) one hundred and fifty pounds each in weight, forming a layer of (5) five feet in thickness and (52) fifty-two feet in width at the top of the bed of the lake, which is about (18) eighteen feet in depth along the line.

The rubble foundation is the only portion of the work to be put in place during the year 1877,—the cribs may be framed and put together, but will not be sunk and filled with stone until the spring of 1878, so as to allow time for the possible settlement of the foundation, upon the amount of which the number of courses of crib-work will depend.

Immediately after the cribs are sunk, they will be protected on each side by a rip-rap of heavy stones, weighing each not less than one ton, which will be thrown in so as to accord as nearly as practicable with the official drawings, and as directed by the Engineer officer in charge, or his agent.

No superstructure will be put on until all the cribs are in place, nor is it desired that the work should be fully completed before the date limiting the contract, (September 30th, 1878.)

The unfinished superstructure of the three cribs sunk in 1876, is also to be finished. This may be done during 1877.

Work must be commenced within thirty days after notification of acceptance of bid, and the whole completed on September 30th, 1878.

Timber and lumber to (5) five feet or more below standard low water, must be of good white or hard pine or white oak, distributed as may be directed by the authorized agent of the U. S. Below the level of (5) five feet below standard low water it may be of white hemlock. All, both above and below water, must be of the best quality of its kind, free from splits, shakes, decay, rotten knots, and all other defects tending to impair durability or strength, and must be truly and squarely sawed to full dimensions. Timber may be counterhewed if preferred, but truly and squarely, and to full dimensions.

Iron—Head, nut, screw and washer bolts to be round, of lengths as specified in bill of material, one and one-fourth (1¼) inches diameter; each bolt to be made with one head, one nut and screw, and to have two washers. Heads and nuts to be two and one-quarter (2¼) inches square, and one and one-eighth (1⅛) inches deep. Washers to be four inches (4) square, three-sixteenths (3-16) of an inch thick, and cut to fit the bolt. Threads to be cut for a length of three (3) inches, and seven threads to the inch; all the parts to be so made as to assemble truly and accurately, to be interchangeable and to have full bearings.

Drift bolts to be one (1) inch square and cut to assorted lengths, as specified in bills of material.

Spikes to be ordinary ship spikes of assorted lengths, as specified in bills of material.

All iron material must be of the best quality of wrought iron and of exact dimensions specified, and any bolts or spikes failing in driving from any cause, must be replaced by the contractor for iron.

The contractor for construction of the breakwater will be held responsible for all material until it is used in the work.

All work must be done in a workmanlike manner, strictly in conformity with the plans and specifications, or such modifications of the same as may be made by the Engineer officer in charge, or through his instructions to his Assistant or Inspector.

Cribs to be framed and built in accordance with plans and specifications, and to the entire satisfaction of the Engineer officer in charge, to be placed and fastened in position as required by him, then to be filled with stone, leveled and covered with superstructure.

Superstructure must be well and squarely built and securely bolted, and before being accepted must be filled with stone flush to the decking, and planked over.

Framing must be done accurately, and care taken in handling framed timber not to chip off the edges or split the dovetails. In framing timber, no stick must be so cut as to fall easily into its place, but on the contrary, each stick will be required to be mauled into place, and subject to the foregoing paragraphs.

To prevent splitting while bolting, timber, plank and joists must be bored to receive the bolts. Boring for bolting will in no case be allowed of the same diameter as bolts, but always slightly less.

Payment will be made monthly on Inspector's returns, retaining ten (10) per centum until completion of the contract.

The iron material must all be delivered before the first (1) of August, 1877, and will be paid for as soon thereafter as practicable.

The rubble stone of the foundation will be measured in the scows, if thus delivered. If in vessels, the weight and cubic contents will be determined in a manner satisfactory to the Engineer officer in charge.

These specifications will form a part of the contracts.

Detailed bills of material will be furnished the contractor.

C. E. BLUNT,
Lieut. Col. of Engineers.

For Iron Landing Pier.

SPECIFICATIONS

FOR IRON FOR LANDING PIER NEAR LEWES, DELAWARE.

U. S. ENGINEERS' OFFICE,
No. 1328 Chestnut St.,
PHILADELPHIA, PA., March 31, 1877.

See pages 210, 219, 251.

The pile shafts will be of hammered iron, swedged smooth and true to dimensions. Shafts.

The heads of the piles must be faced on the top, and turned on the sides, to fit the caps, as shown on the drawings. Heads.

The necks must be turned on the pile shafts, and the collars or clamps turned inside, to fit each other, as shown on the drawings. Necks.

The foot of the pile shafts to be smooth forged and faced on the bottom, to accurately fit the socket of the screw, which will be cast as smooth as possible on the sides, and faced on the bottom to receive the foot. Foot.

The braces will be of rolled iron; the eyes of the tension braces will be formed by a turn and weld with a long scarf. Braces.

There will be no welding to form the length of the braces. Welds.

Screw-ends to be "upset," or fulled on the bars to drawing dimensions. Screw-ends.

The threads to be full cut from solid metal. Franklin Institute standard. Threads.

Screws. Screws of the turn-buckles must be cut from solid metal, one end with a right, and the other with a left hand thread.

Bolts. Bolts must be forged to fit *body bound;* diameter to be uniform the entire length; no enlargement under the head.

Bolt-holes. Bolt-holes in braces, lugs and clamps, to be drilled to fit body-bound bolts.

Forgings. Forgings and rolled iron must be smooth, and without flaws.

Material. Material to be fagoted scrap iron.

Strength. Wrought iron must bear an ultimate tensile strain of 60,000 pounds to the square inch of cross-section, and a strain of 24,000 pounds to the square inch without taking a permanent set. **Set.**

Castings. The castings must be of tough gray iron, cast in dry sand, sound, true and smooth.

Strength. Cast iron must bear an ultimate tensile strain of 25,000 pounds, and a transverse strain (to the foot length) of 600 pounds to the square inch.

Fnishing and fitting. Machine and hand work, and finishing to be without fault. All parts belonging on or to others to be put together in shop to insure fits.

Testing. The U. S. Inspector to select such pieces as he wishes for testing.

Pieces. Pieces for testing will be cut off and turned to the required dimensions, and tested either at the place of manufacture or elsewhere.

Castings. Castings for testing will be run as required by the Inspector.

Expense. All expense of testing to be borne by the contractors.

Full metal. Full extra thickness of metal must be provided for all turning, boring, facing, and finishing required.

Marking. All pieces must be marked with chisel or punch, or with paint, as may be required.

Inspector. Access to the work, and works, must be free at all times to the U. S. Inspector.

Dimensions. Collars, clamps, turn-buckles, bolts and nuts, of proportionate dimensions. Caps and screws to correspond.

Material.

Rolled Iron—					
Upper cross braces,	24—14′ 4½″×2¼″ diam.,	5280	lbs.@	cts. per lb.	$
Lower "	24—20′ 7″ ×2½″ "	8400	" "	" "	"
Longitudinal "	30—26′ 10¼″×3″ "	19800	" "	" "	"
Bands for screws, 15		240	" "	" "	"
Hammered Iron—					
Pile shafts, 15—15—55′×8½″ diam.		156000	" "	" "	"
Screw-buckles, 54		2652	" "	" "	"
Yokes for cross braces, 24		1200	" "	" "	"
Bolts and Nuts, 174		4002	" "	" "	"
Collars and Clamps, 30		6720	" "	" "	"
Cast Iron—					
Screws, 15		6300	" "	" "	"
Caps, 15		9756	" "	" "	"

Total bid for material .... $

The contract price will be determined on this total, but the right to vary amounts and dimensions is retained by the United States. The *prices per pound* will not be changed.

The above prices are for iron delivered either at the U. S. Landing Pier, or at the Railroad Pier, near Lewes. Place of delivery.

The material for each bay complete (5 piles with braces, screws, &c.) shall be delivered at the same time in order that there may be no interruption in the work of construction; and in case such interruption should occur through non-compliance with this specification, the contractor shall be liable for all loss to the Government accruing therefrom. Delivery.

A bay complete shall be delivered not later than June 5th, and the remaining two not later than August 5th, prox. Delivery.

All material when ready for delivery shall, previous to shipment, be inspected at the works by the U. S. Inspector, and any material rejected by him shall not again be offered for inspection. Inspection at the works.

Upon delivery at Lewes all material will be weighed and again inspected by the Engineer Officer in immediate charge of the work, and if any be then rejected it shall be replaced by the contractor without expense to the United States. Inspection at the pier.

All surfaces of iron work must, subsequent to the inspection at the works, receive two coats of Spanish brown, or brown zinc, ground in oil, as may be required, thoroughly put on, *at the workshops*, and left to dry for some days before shipment. Paint.

All bright surfaces to be similarly protected with white lead and tallow, or with white lead and oil. Paint.

Signature,..............................

For removing Snags, &c.

SPECIFICATION

FOR THE REMOVAL OF SNAGS, &C., FROM THE MINNESOTA RIVER.

See pages 211, 219, 222, 251.

U. S. ENGINEERS' OFFICE,
ST. PAUL, MINN., June 2, 1877.

The work will consist of removing snags and boulders from the channel, and cutting down and removing overhanging trees from the banks of the Minnesota River, between St. Peter and Mendota, at such points as may be designated by the Engineer Officer or Inspector in charge. Nature of work.

Trees, snags and boulders must be totally destroyed or placed beyond the reach of high water, at places to be designated by the Engineer Officer or Inspector in charge of the work. Place of deposit.

The prices for removing snags, boulders and overhanging trees must include all the labor, machinery, and other appliances necessary to do the work. Price.

The contractor will not be permitted to take any advantage of an error or omission in the foregoing specifications, as full instructions will always be given should such error or omission be discovered. Stipulations.

The boulders removed will be measured in cubic yards, after the same are removed and piled. Measurements

The trees will be cut off at a height not to exceed one (1) foot from the ground, and the measurement will be made at the cutting.

Snags will be measured two (2) feet from the highest root.

Payments will be made at the end of each month, to include the work done on the last Saturday of the same—ten per cent. being retained from each payment until the completion of the work. Payments.

The work will commence as soon as the stage of water will permit, after the signing of the contract, and must be prosecuted with due diligence until the funds available ($10,000) are exhausted. The time not to extend beyond the first day of April, 1878. Work to commence

Approximate Quantities to be Removed.

50	cubic yards Boulders.		
26	Trees,	36 in. and upwards in diameter.	
75	"	30 in. to 36 in. in diameter.	
224	"	20 in. to 30 in.	"
474	"	6 in. to 20 in.	"
201	"	4 in. to 6 in.	"
47	Snags,	36 in. and upwards in diameter.	
102	"	30 in. to 36 in. in diameter.	
212	"	20 in. to 30 in.	"
496	"	6 in. to 20 in.	"
143	"	4 in. to 6 in.	

F. U. FARQUHAR,
Maj. of Engineers.

For Canal Locks.

SPECIFICATIONS

FOR THE CONSTRUCTION OF FIVE CANAL LOCKS ON THE MUSCLE SHOALS CANAL, TENNESSEE RIVER.

See pages 211, 219, 224, 251.

U. S. ENGINEERS' OFFICE,
CHATTANOOGA, TENN., April 18, 1877.

Specifications.

TO BIDDERS.

The locks, for the building of which bids are invited, are numbers 6, 7, 8, 9 and 10; but awards will only be made for such of these as the prices bid and amount of funds available may warrant.

The lock chambers are to be about 300 feet long, and 60 feet wide, with side walls from 13 to 20 feet high.

The lock pit excavations will be about 370 feet long by 80 feet wide, and will be carried down to, or into solid rock when required. Concrete floors will be used where the rock is found so cracked and unreliable as to render them necessary.

Bids will be received in the two following forms, and not otherwise:

(*a.*) *For a single lock, giving its number.* Each bidder being, of course, allowed to bid on as many locks as he chooses; submitting a *complete, distinct, itemized proposal for each:*

(*b.*) *For the whole work to be let* under these specifications, provided at least *three* locks are awarded to the bidder. These bids are also to be itemized as indicated on the annexed "Form of Proposals." The contract will then be awarded on the separate bids or on an aggregate bid, whichever will secure the completion of the work at the lowest cost to the United States.

If, under these provisions, it is decided not to award contracts for all the locks mentioned, the Government will designate which locks are to be omitted.

It is assumed that every bid is made in the interest of the bidder, and that he expects to make a fair profit on the work. If, therefore, items of any bid are manifestly below their actual and necessary cost, it will be attributed either to the ignorance of the bidder or a design to gain some unfair advantage, and such bids will not be accepted.

Each bidder should state whether he has ever been engaged in building canal locks, or similar works, or has ever been interested in any contract with the United States, and if he has been so interested, he will give the date and character of the contract.

Special attention is directed to the Instructions for bidders, attached hereto. Bids not made in conformity with these instructions will not be entertained.

These specifications will be attached to, and form part of, the contract. Bidders are advised to read them carefully and to visit the work at Muscle shoals. An Assistant Engineer, stationed near Shoal Creek, about 8 miles from Florence, Alabama, will be prepared to furnish all necessary information as to the location and surroundings of the work.

General Conditions.

The entire work must be executed in accordance with working drawings, furnished from time to time by the Engineer; and all orders and instructions given by the Engineer, relative to the prosecution of the work or details of construction, shall be promptly and fully complied with by the contractor.

The Government reserves the right to make such alterations in the plans, location and details of the work as shall seem advantageous; and it is to be distinctly understood that any increase or reduction of quantities, resulting from such alterations, is not to be assumed as the basis of a claim against the Government for damages or for the loss of prospective profits.

The contractor will not be allowed to take advantage of any defect or omission, either in the drawings, specifications, or instructions given by the Engineer. In such cases, or in any doubtful case, it is his business to bring the matter to the attention of the Engineer, who will make all necessary corrections or explanations.

All *materials and workmanship* must be such as are approved by the Engineer in charge, and must be carefully examined either by himself or by a duly authorized Inspector acting for him. Rejected materials must be removed at once from the vicinity of the work; and no payment will be made for materials so rejected or disapproved.

Stone and other *materials* will be *paid for only* when permanently placed in their final position in the work, and are then approved and accepted by the Engineer.

The contractor must protect his work until it is completed and duly accepted, and he must repair any damage done to it by freshets, rains or other accidents, in such manner as the Engineer may direct, at his own cost.

Before receiving his final payment he must, unless otherwise directed, at his own cost, remove all unused materials, dams, and other temporary works used by him, and leave the work in a neat and orderly condition.

No *convict labor* will be allowed on the work, nor will the contractors be allowed to interfere with each other, nor to obstruct the roads required for the use of other contractors or of the Engineers; nor to retain on the work men who are disorderly, or who attempt deception or evasion in carrying out these specifications.

Work must be begun within thirty (30) *days after the execution of each contract, and must be completed by June* 30, 1878. A fair monthly progress must be made.

Excavation.

The *prices bid* for excavation will be estimated *per cubic yard,* measured in position, and must include the clearing and grubbing of the site, building dams, pumping and draining, and the excavation, removal, and deposit where directed by the Engineer, of all the materials of whatever name or nature, that may be encountered in preparing for the foundations of the locks.

The *excavated materials* will be deposited where the Engineer considers they will be most advantageous to the whole work; and, if he so directs, they must be left in regular and evenly distributed masses.

When materials are required by the Engineer to be hauled more than two hundred feet from the lock pit, an allowance of one (1) cent per cubic yard, for each additional hundred feet of haul will be made, but no allowance of this kind will be made where the materials are deposited within two hundred (200) feet of the lock.

No allowance will be made for excavation below the grade nor outside the limits given by the Engineer.

All the excavation will be classified as follows, the Engineer being the judge as to which class any material encountered belongs:

(*a.*) *Earth Excavation.* This will include clay, sand, gravel and all other earthy materials, (except hard pan, as specified in the following paragraph,) and loose stones, not larger than one cubic foot each.

(*b.*) *Hard Pan and Loose Rock.* This will include tough, indurated clay, hard, tough, cemented gravel; and other earthy materials which, in the opinion of the Engineer, require blasting, or at least three times the usual amount of picking; boulders containing from one cubic foot to one cubic yard, each; and all slate, shale, stratified limestone and sandstone that, in the opinion of the Engineer, can be removed by picking and without necessarily using explosives. As it is not known what quantity, if any, of these materials will be encountered, "Hard pan and Loose rock" will not be bid for as a separate item, but one-half of the quantity excavated will be paid for as "solid rock," and one-half as "earth excavation."

(*b.*) *Solid Rock.* This must be such as to require blasting, or some more expensive method, to reduce it to masses of less than one cubic yard each, that can be handled with a derrick. When the Engineer shall require any part of the rock in place to be pointed or axed to true surfaces for face work, an allowance will be made of 20 cents per square foot of surface dressed, in addition to the contract price, per cubic yard, for the quantity of rock actually removed. This provision relates only to cases where, as in lock 9, it is proposed to use the rock in position for a part of the side wall without masonry facing. In all cases the surface of the rock must be prepared at the cost of the contractor to receive the masonry, being stepped, if required, for that purpose.

(*d.*) *Old Masonry.* This will include the removal of such of the old locks as are hereafter designated. In this work blasting will not be allowed, and will not probably be desirable to the contractor. The stones must be handled carefully so as not to break or injure them, and such of them as are approved by the Engineer will be used in the new locks, an allowance being made therefor by the contractor, which must be specified in the bids. These stones must be re-cut if used as "cut-stone."

Bidders for Lock No. 6 will bid on the removal of old lock No. 10.

Bidders for Lock No. 7 will bid on the removal of old locks Nos. 11 and 12.

Bidders for Lock No. 8 will bid on the removal of old locks Nos. 14 and 15.

Bidders for Lock No. 10 will bid on the removal of old locks Nos. 16 and 17.

Certain parts of old locks Nos. 14 and 17, to be designated by the Engineer, may be retained for future use, and such parts must not be disturbed in removing the balance of the stones. Any stone designated to be left and which is disturbed by the contractor, must be re-set at his own cost.

Masonry.

The masonry will be of four kinds, viz: *Cut Stone*, *Rock Face*, *Rubble*, and *Concrete*.

The bids must state the price per cubic yard laid, for each class, and **must**

include all labor, tools, and materials required to quarry, haul and cut, or otherwise prepare the stones and put them in their final position, and the building in of all iron and wood work that may be furnished by the United States for that purpose.

The *lock pits* must be freed from water by the contractor before masonry of any kind is begun, and any masonry laid in water or submerged before it has had time to thoroughly set, shall be taken down and replaced by the contractor at his own cost.

No cutting, drilling or *hammering* of stones will be allowed after they have been brought *upon the wall;* and they must be lifted by derricks or cranes and lowered into their places without shock to the masonry. Any stone whose bond or set is disturbed by a neglect of these precautions, must be taken up and re-set at the cost of the contractor.

Not more than three courses of either wall of a lock must be unfinished at a time; and the backing must go up with the facing, but never in advance of it.

Every surface which is to come in contact with mortar must be freed from dust and dirt, and thoroughly sprinkled just before the mortar is applied.

Every stone, both of the facing and of the backing, must be set or laid in a *full bed of mortar*, and great care must be taken that the vertical joints are thoroughly filled with the same, well forced in with the trowel.

All *stone* used must be quarried without blasting, and must be sound, strong and durable, free from seams, scales or earthy matter, and of a kind not easily injured by frost or water. Stone quarried after the 1st of October will not be placed in the wall before the 1st of April following, unless by special consent of the Engineer.

All the *mortar* used in these locks will, unless otherwise specially directed by the Engineer, consist of two parts, by measure, of sand and one part of hydraulic cement, with only enough water to form a paste, stiff enough to handle with a trowel. Mortar must be used as soon as it is thoroughly mixed, and if allowed to set before using, it must be thrown away. *No grouting* will be used on the work except by special direction.

No work involving the use of mortar will be done while the temperature is below 35° Fahrenheit.

The *cement* must be freshly burned and ground, and equal in all respects to the best Louisville brands. It should be finely ground, and free from moisture or inert matter, and must set strongly and firmly. Every barrel will be tested, and such as are rejected must be removed at once from the vicinity of the work. In order to avoid deterioration, contractors are advised to provide cement sheds, and use every precaution to keep the cement thoroughly dry. No common or fat lime, or cement that fails to pass the tests, is to be used in any part of the work.

The *sand* must be clean, sharp and free from vegetable matter, and must be screened and washed if required by the Engineer.

Cut stone, where used as *facing*, must be laid in regular courses, headers and stretchers; no course to have a less rise than (18) inches. Each stone to have at least one-fourth (¼) more bed than rise, and a length not less than twice, nor more than four times the rise or thickness of the course. The *bond* must be at least one foot in all cases.

The *hollow quoins*, if required, (it is probable that the gates used will be such as to dispense with at least one pair of hollow quoins,) must be cut in a single stone in each course, at least (4) feet wide and seven (7) feet long, laid alternately as headers and stretchers. *Mitre sills* will *not be built* under these specifications.

The *coping stones* must be at least three (3) feet wide and five (5) feet long, or must have a bed of at least fifteen (15) square feet. The thickness of the coping must be at least eighteen (18) inches, and each stone must be dressed true on all sides but the back, which will simply have a straight line "pitched" along its upper edge.

The *faces* of all cut stone and the *top* of the *coping* will be dressed with care, either thoroughly axed or bush-hammered to true, even surfaces, with clean angles and perfect edges, and without marking or spalling. The curved surfaces of the hollow quoins must be made particularly smooth and true.

The *beds* and vertical *joints* must be pointed down to true planes without projections or cavities; the former eighteen (18) inches and the latter ten ten (10) inches back from the face, to admit of being set with one-fourth (¼) inch joints. The remaining parts of these surfaces to be broken or pointed off, to admit of joints not more than one (1) inch thick. Beds are to be cut parallel with the quarry bed, and vertical joints to be perpendicular to the beds and to the face of the wall.

The *quantity* of cut stone masonry will be computed by allowing two feet thickness measured from the face of the wall; but *no constructive measurement* will be made at corners or openings, or in other words, no part of the wall will be measured twice. The coping and hollow quoins will be measured as cut stone throughout.

Rock face masonry will be the same, in all respects, as the cut stone, excepting that the face will have a straight line pitched around it, instead of being cut to a plane surface. No part of the surface will, however, be allowed to project more than one inch from the pitch line, unless authorized by the Engineer, for special localities. This class of masonry will be measured in the same way as the cut stone.

Rubble will be built of stone at least nine (9) inches thick, and each stone must have at least one-fourth more bed than rise, and a length not less than twice nor more than four times the rise. The coursing may be irregular, excepting that when used as backing it must course with the facing, and where it is used as facing it must bond with adjoining face work. To accomplish this, stones of a smaller size than those just prescribed may be introduced to a limited extent, when authorized by the Engineer.

The stones must be broken or pointed down to regular, even surfaces, square with each other, to lay with joints not more than one inch thick.

The stones must bond together at least nine (9) inches, and headers at least four (4) feet long must be inserted at intervals of ten or twelve feet, each header falling over the interval between two headers in the course next below.

The *rubble* will be measured in the same way as the cut stone, excepting that the actual thickness of the rubble will be taken, including those portions of face stones not measured as cut stone or rock face; but in no case shall the thickness of wall or any other dimensions of the same as measured be greater than the dimensions shown by the drawings, even if the contractor has exceeded those dimensions.

Concrete. When concrete is ordered for any part of the work, it must be made of three parts, by measure, of coarse gravel, or broken stone, small enough to pass through a ring 2½ inches in diameter. and one part of the mortar already described.

The *stone* or *gravel* must be hard, strong, and free from dust, and must be wet or washed before mixing with the mortar, if required by the Engineer.

The *ingredients* must be thoroughly mixed by hoe and shovel, or by a concrete mill, so that every piece of stone or gravel shall be entirely coated with the mortar.

Concrete must be laid as soon as it is thoroughly mixed; the mass being deposited in successive layers not more than six inches thick, and each layer being thoroughly rammed before the next one is laid. The concrete must be mixed so dry that no signs of water will appear until the ramming is nearly completed.

Concrete will be substituted for rubble backing, filling, &c., to the extent required by the Engineer, and the quantity of concrete measured, will be the actual number of cubic yards, so required and laid.

Approximate Quantities.

In Cubic Yards, Measured in Position.

	EXCAVATION.			MASONRY.				ALLOWANCES.		
Number of Lock.	Earth Excavation.	Solid rock Evcava'n	Old Locks.	Cut Stone.	Rock Face.	Rubble.	Concrete.	Stone from Old Locks, used as Cut Stone.	Stone from Old Locks, used as Rock Face	Stone from Old Locks, used as Rubble.
No. 6.	10000	500	1100	530	420	1300	200	50	100	150
No. 7.	5000	3500	2200	700	450	2500	350	100	200	300
No. 8.	3500	1200	2000	800	450	3000	400	100	150	200
No. 9.	5000	4000		350	300	1400	250			
No. 10.	8500	4100	2000	700	450	2500	350	100	200	400

It should be distinctly understood that these quantities are only approximations, some of them being of such a nature as to be impossible to estimate with any degree of accuracy until the work is in progress. Slight changes in the grades, or in the location of the line, which may be made in consequence of facts hereafter developed, may cause great variations in the quantities herein given.

W. R. KING,
Captain of Engineers.

For a Dam of Masonry.

SPECIFICATIONS

FOR DAM NO. 4, NEAR CABIN CREEK, ON THE KANAWHA RIVER.

U. S ENGINEERS' OFFICE,
BALTIMORE, MD., March 1, 1877.

See pages 211, 219, 225, 251.

The works consist of a Dam, Abutment, Pier, and the floor of a Navigation Pass, adjoining Lock No. 4 of the Kanawha River Improvement, near Cabin Creek, West Virginia; all of which are shown by the drawings.

The dam or weir will be of masonry, *about* 200 feet long, 14 feet high from the rock, (which is about 11 feet below extreme low water surface of the river,) and 16 feet thick at base; with a batter on the face and rear. It will be covered with heavy stone, to which the longitudinal timbers shown on the plans will be bolted, and the space between the timbers filled with squared, dressed rubble, all to be well dowelled. The abutment will be of masonry about 16 feet higher than the dam, about 35 feet long, with return walls, securely connected with the bank. Walls will be about four and a half (4½) feet thick on top, with a batter on the face. They will be coped with heavy stone, well dowelled. The abutment will be filled with solid material, (earth, gravel, &c.), and protected over its entire upper surface with a heavy paving laid in mortar on a course of concrete.

The pier, which will separate the dam from the navigation pass, is about 50 feet long, 10 feet thick, and rises 9 feet higher than the dam.

The floor of the navigation pass will be a platform 250 feet long, about 50 feet wide, and 5 to 6 feet thick. Its upper surface will be about 5 feet under water at low stages. It will be composed of a grillage or crib-work of timber filled with concrete, covered with a stone pavement in mortar. The main sill and such other parts as the Engineer may direct, shall be of cut stone. This portion of the work is represented as to its general character only, subject to variation in arrangement of the details of its surface.

The lock which these works adjoin is already under contract, and in process of construction.

The works will conform to the drawings exhibited, and to such others as may be furnished from time to time.

The contract will cover the necessary dredging and excavation and other preparation of the site, all coffer-dams, pumping and bailing, embankment, puddling, masonry and timber work, the grading and protection of the bank; and the entire construction and completion of the work.

Grubbing and clearing will cover the removal from the site of all trees, bushes, stumps and roots, as well as snags, stumps and roots under water.

Excavations will include all materials removed from foundations, for channels, for coffer-dams, in grading the river bank, and to obtain material for embankments. They shall conform to such lines and levels as may be given by the Engineer, and be deposited at such places as he may direct, being used as far as possible to make the necessary embankments, The contract price will cover the cost of transportation and placing in bank. Rock in place or other material so hard that it can best be excavated by drilling and blasting, and boulders of more than 9 cubic feet shall be classified as "Rock excavation;" all other material as "Earth excavation."

Embankments include the filling behind abutments and walls, the gravelling of the dam, and such as may be required to fill out and grade the river bank. They will be composed of material from the excavations, or borrowed at such point as the Engineer may direct. Whenever practicable, they will be measured and paid for as excavation only; where this is not practicable, the materials will be measured in embankment and paid for at the price of excavation, without allowance for increase or shrinkage. When placed above water, they shall be carted on, and spread in layers of ten inches; or if carting is impracticable, they must be spread in 6 inch courses and well compacted by ramming. Embankments in contact with masonry, shall be puddled for such thickness as the Engineer may direct.

Puddling will be composed of clay, or clay and gravel mixed in nearly equal proportions, it shall be spread in eight inch layers, thoroughly wet, and cut and worked into a homogeneous water-tight mass. The price to be in addition to the excavation price, and the material to be measured in the bank.

Coffer-dams will be built by the contractor subject to the approval of the Engineer; the cost of the same as well as all pumping, bailing, and repairs to be covered by the prices for masonry. They will be kept in order and kept clean by the contractor, but he may be paid for the removal of material deposited in them by floods, at his excavation price per cubic yard, unless due to delay or neglect on his part, of which the Engineer will judge.

Foundations.

The whole space to be covered by the works will be excavated to the solid rock, together with any pits for anchor plates which may be required, and any loose or soft rock shall be removed as the Engineer may direct. The masonry of the abutment, weir, and pier will be built directly upon the rock, which shall first be cut into good horizontal beds for the first course of face stone, so that each stone may have a full bearing. These stones however may vary in height and be levelled up on top with levellers or by checking. Rubble and concrete backing shall rest on and be

attached to the sound clean bed rock. The necessary bolts, plates, &c., will be inserted as the work progresses.

Masonry.

The coping, the rounded corners of the abutment and pier, the borders of openings in them, and the sills of the navigation pass, will be of cut stones. The vertical face on the abutment, the coping and paving of the dam, and the lateral faces of the pier will be of dressed rubble. The face and wings of the abutment, the face of the dam below the coping, and the ends of the pier will be of rock faced masonry; and the backing of all walls will be of rough rubble or concrete, as the Engineer may direct.

All stone shall be perfectly sound, hard, strong, not affected by frost, free from seams or quarry scale, and to ring under the hammer. Stone for cut work to be such as can be truly wrought to such lines and surfaces as may be required, whether curved or plane, and all stone for the same class of work to be as nearly as practicable of uniform color and appearance.

Cut stone shall be in courses not less than 16 inches high, each stone to have at least one-fourth more bed than height. The general dimensions and arrangement of cut stone are shown by the drawings. The beds and joints will be dressed with care, true and out of wind, without slack or want on the beds; the joints to be full for 12 inches from the face, to lay with three-eighths of an inch joint. The face will be cut true and to the proper lines, with clean, sharp arrises free from spalled places, and formed by narrow drafts on the beds and joints, as well as on the faces of the stone. The edges of cut stone which adjoin masonry of a rougher class shall have a bevel or rustic of one and a quarter inches; the edges of all grooves and recesses to be slightly rounded. Any stone having defects concealed with cement or other material shall be rejected on that account alone.

Coping will be of uniform thickness throughout each course; not less than 18 inches thick, and shall conform to such plan as may be furnished by the Engineer. It shall be cut fine on the top and face, and pointed off to good, fair beds and joints, with clean straight arrises around the face, and upper surface of the stone, except the upper front edge, which shall be rounded to a radius of 2 inches. To be well dowelled with two cast iron dowels for each stone; dowels ten inches long with swelled heads, run in with Portland cement.

Dressed rubble to be of squared stone not less than 10 inches high, with no bed less than 18 inches, or less than the height of the stone, and the beds of two adjacent stones shall vary in breadth at least six inches. One-fifth of the face to be headers four feet long or longer. Stones intended to course together shall be of uniform height, to be so arranged where they bond with cut stone that the beds of one class shall correspond exactly with those of the other, but courses may vary by checking, or by an occasional leveler, not less than four inches high, Beds shall be dressed entirely through, and every stone shall be set on its best end; joints to be full for six inches from the face, and all beds and joints to be normal to the face or

at such angle as may be prescribed. Both beds and joints will be pointed down to fair, plane parallel surfaces to lay with five-eighths of an inch joints. The faces shall have no projection over three-fourths of an inch from the drafts.

Rock faced masonry shall be similar to the above, but the face may be left rough, but with no projection greater than 2½ inches—each stone to have a draft around the face of one and a quarter (1¼) inches or to be neatly pitched off at an angle of 45 degrees as the Engineer may direct.

Rough rubble for backing shall be of large, clean, well shaped stones, hammered to good fair beds so that they will lie solid; all to be well bonded. Cutting or dressing a stone after it has been set is prohibited—except in special cases by consent of the Engineer.

Concrete shall be composed of broken stone or gravel, which will pass through a 2½ inch ring, free from dust and dirt, to be screened if required by the Engineer. To be thoroughly mixed, (with sixteenths of its bulk of mortar,) carefully put in place by such process as the Engineer may approve, and rammed or pressed into a solid mass.

Paving will be of hard well shaped stones of even thickness, sixteen inches in depth, laid in mortar.

Slope walls of dry rubble masonry will be made of well shaped stone, hammered to fair beds generally 18 inches wide, laid to the proper lines and slopes, and at right angles to the slope and to reach through the wall on a bed of gravel or spalls six inches thick, and shall be finished on top with wide stone, jointed. The face to be well wedged and pointed with pinners and spalls.

Rip-rap and filling for cribs will be of sound rubble stone as specified above, such proportion as the Engineer may require, to measure one and a half cubic feet each. Such portion of the gravelling of the dam as the Engineer may direct, shall be made of "rip-rap" and paid for at rip-rap price.

Cement will be of good and uniform quality, setting firmly and strongly, but not too quickly; subject to the approval of the Engineer, and to constant inspection. It must be a fine dry powder, free from cinder or other inert or injurious substance, and kept under cover in a tight shed or cement house.

Sand to be clean, sharp, silicious; to be screened and washed if required by the Engineer.

Mortar to be composed generally of two parts of sand to one of cement, well and thoroughly mixed, and used before it has begun to stiffen. It must not be used on the "second set." For concrete in foundations not exposed to running water, the mortar may with the consent of the Engineer have two and a half parts of sand to one part of cement.

Laying masonry.

All stones to be well and solidly laid to the proper lines, in full beds of mortar, and settled in place with a wooden maul. The joints of face stone to be well filled with the trowel or other tool. Rubble stone in backing will also be laid perfectly solid in full beds of mortar, the

joints to be well filled with the same; all space shall be filled with mortar, into which spalls and selected pieces of stone shall be driven until the whole is full. The use of grout or fluid mortar is prohibited.

Face stones may with the approval of the Engineer be backed with concrete in layers corresponding with the courses of stone, rammed solid.

Proper machinery must be used in handling large stones, and every stone, the bond of which is broken, must be taken up and reset.

The bond of stone will in no case be less than eight inches.

Face work will be jointed and pointed as the work progresses, with the same mortar with which it has been laid, pressed in, and smoothed or burnished with a proper tool.

Masonry will not be executed during freezing weather, except by consent of the Engineer, who will prescribe what precautions shall be taken to prevent injury to the work; and all new and unfinished work shall be properly protected by the contractor at his own cost.

The contractor shall build into the masonry. without extra charge, all the iron work and timber, sills, anchors, plates, &c.

Timber shall be white oak or white pine, or such other as Timber.
may be approved by the Engineer officer in charge, sound, straight, free from shakes, cracks, loose knots or other defects impairing its strength, durability, or fitness, and subject to the approval of the Engineer, properly sawed or hewed to prescribed dimensions, the surfaces to be fair, and out of wind. Where the use of flatted timber (that which is hewed or sawed only on two opposite parallel faces,) is permitted by the Engineer, the contractor shall be paid for so much only as the log will square. The price of timber shall cover the cost of framing and placing of nails, spikes and pins.

Iron work will be furnished by the United States, and built into the work by the contractor without extra charge.

Earth and rock work will be measured in excavation, and Measurement.
the price per cubic yard will cover its transportation and placing in embankment.

Concrete and rough rubble will be paid for by the cubic yard in place.

Dressed rubble and rock faced masonry will be measured and paid for by the cubic yard for an average thickness of face, to be determined by the Engineer, and to which the work in execution must conform.

Cut stone masonry and coping, will be paid for by the cubic yard, measured before the stones are laid.

Timber and plank by the 1000 feet, board measure, of the dimensions prescribed and furnished.

The prices for masonry shall cover all coffer-dams, pumping and bailing, machinery, &c., as well as drilling and cutting for bolts and dowels, and generally the prices bid will cover all expenses incident to the work.

All material rejected by the Engineer shall be piled in General conditions.
sight near the works, and so remain until the same are completed.

Within thirty days after the completion of the works, the contractor

shall remove from the site all coffer-dams, rubbish, old and unused material, and leave the whole in perfect order and condition. The slopes of all excavations and embankments shall be neatly finished and trimmed to the prescribed slopes, the top and bottom edges correctly lined off and defined. In their first execution they will be left full, so that there may be some earth to remove in the final dressing. This dressing will be covered by the contract price for excavation and embankment.

From sunset to sunrise the work shall be lighted in such manner, satisfactory to the Engineer, as to prevent accident to boats navigating the river. This lighting shall be done by the contractor at his own expense, and he shall be liable for any and all damages due to neglect in this particular.

The work will be conducted under the direction of the local or resident Engineer, who shall have power to prescribe the order and manner of executing the same in all its parts; of inspecting and rejecting materials and work which do not conform to the true intent and meaning of the drawings and of these specifications; but the decision of the United States Engineer officer in charge of the works shall alone be final and conclusive upon these points, and upon all questions arising out of these specifications, and from his decision there shall be no appeal. Within one month after the award of the contract, the contractor must elect a residence, to which all letters and notifications concerning the work may be sent.

The work must be commenced within thirty days after the execution of the contract, and completed by or before the 31st day of December, 1878.

Payments will be made monthly, reserving 10 per cent. of **Payments.** all monthly estimates until the completion of the whole work; and no payment will be made for material until it is actually in place in the work and has been inspected and accepted. But if the contractor, in judicious prosecution of his work, should prepare non-perishable material in advance of the proper time to put it in the work, the Engineer in charge may, at his discretion, pay him for such material, after inspection and delivery to the United States, a proportionate part of his contract price for the finished work, to be deducted from the final estimates when paid.

Extra work shall be done only upon the written order of the Engineer, when time will permit; the quantity and value to be agreed upon in advance when practicable, or if impracticable, then immediately thereafter and within the next 30 days succeeding.

The right is reserved to make such changes in the plans and specifications of this work as the Engineer in charge may think proper, and in case such changes shall increase or diminish the expense of doing the work, it shall be his duty, with the approval of the Chief of Engineers, to add to, or deduct from the contract prices in proportion to such increase or diminution.

In the event of the appropriation being exhausted before the completion of this work, or for other sufficient cause, the right is reserved to the U. S. Engineer in charge to suspend the contract without liability on the part of

the United States, upon giving thirty days notice thereof. In which case all the work done and materials furnished will be paid for in full, together with the reserved percentage.

In case this contract should fail or be annulled, all coffer dams and cribs, with all their adjuncts, appurtenances and accessories shall thereby become the property of the United States; and any and all materials, tools, machinery, boats, tramways, cars, &c., prepared for or in use in the prosecution of the work, together with all leases, rights of way and quarry privileges, may be purchased by the United States at a valuation to be determined by the Engineer.

It is recommended that each person bidding shall visit the site, either personally or by competent agent, ascertain the character of the river as to floods, low water, &c., inspect the style of masonry and other work executed under similar contracts upon other structures of this series, and obtain the information necessary to enable him to make an intelligent proposal. Bidders will state whether these recommendations have been complied with.

All available information will be given at the office of the Resident Engineer, Charleston, Kanawha County, West Virginia.

WM. P. CRAIGHILL,
Major of Engineers.

U. S. Light-House Board.

In this department of the Government service the forms are all similar and some of them necessarily very prolix. A single example will therefore be found sufficient.

SPECIFICATIONS

FOR THE LIGHT-HOUSE ON SOUTHWEST LEDGE, NEAR NEW HAVEN, CONNECTICUT, LONG ISLAND SOUND.

See pages 211, 227, 254.

OFFICE OF THE LIGHT-HOUSE BOARD,
WASHINGTON, D. C., ...1875.

General Description.

The Light-house is to be built on Southwest Ledge, a rock in Long Island Sound, near New Haven, Connecticut. The shoalest point on the rock has on it 11½ feet of water at low tide, and drops off in all directions into deep water quite rapidly.

The uneven surface of this rock was leveled with concrete and small quarry stones, upon which were placed two annular tiers of dimension stones, 28 feet in diameter and 3 feet thick.

On top of this foundation, which is 10 feet below mean high water, was set a cast-iron tube 24 feet in diameter, resting on the stone foundation with a wide bottom flange; it is composed of rings 6 feet high, the lower ring, which is surrounded with rip-rap, being 1 ¼ inch thick, the two next are 2 inches thick, and the upper courses are each 1 inch thick. This foundation is surrounded by a rip-rap protection of large but irregular blocks of granite.

The concrete filling of the tube extends solid up to the cellar, which is 16 feet in diameter and 7 feet high.

The dwelling, which is to be entirely of iron on the outside, will contain, in the principal story, a living-room, kitchen, pantry, and a hall, from which stairs will communicate to the cellar and the upper floors. The roof will contain two stories, two bed-rooms being on the lower and the oil and watch-room on the upper one; above this will be the lantern.

The iron shell of the house will rest on a frame made of rolled-iron beams, which will also support a gallery which is surrounding the entire superstructure.

Communication with the shore will be afforded the keepers by boats, which, when not in use, are hoisted on wrought-iron davits secured to the gallery. Access will be given to the light-house by two ladders from the water to the gallery, which are to be made in two hinged sections; the upper part to be strongly braced and stationary, while the lower one can be hoisted up when not in use.

The gallery is to be protected by a wrought-iron railing, and two coal-slides will lead from the same to the cellar. The cellar to be lighted by two windows, in the top of the caisson. The framework, which carries the dwelling and the gallery, is to be supported on the outside by cast-iron brackets, which are strongly secured to the caisson; the beams to be bolted to them, thus securing the superstructure to the foundation.

The wooden entrance-door to be made in two folds, swinging outward, and will have a transom-light. The stairs are to be inclosed with tongued, grooved and beaded narrow boards from the first-story floor to 2 feet 8 inches above the second-story floor, where they will be cut level and capped.

The pantry to be fitted up with shelves and drawers for storing provisions. In the living-room and the kitchen are to be located two stoves, for heating and cooking purposes; the smoke-pipes to be double, to prevent accidents from fire, and where they pass through the floor an additional ring to be provided, thus forming a double air-space between the smoke-pipe and the floor and ceiling. Drums to be provided in each of the rooms of the second-story for heating those apartments. The smoke-pipes to be carried outside of the roof and finished with Emerson ventilator-caps.

The stairs to be continued from the second-story to the watch-room; the lantern to be reached by a step-ladder, an iron trap-door being provided in the lantern-floor to shut out draughts. A door in the parapet to lead from the lantern to the gallery, which is to be used by the keepers to clean the lantern-glass from the outside; it is to be protected by a plain wrought-iron railing.

In the watch-room there is to be the clock apparatus for the fog-bell, the latter being placed over one of the large dormers which give light to the second-story; proper boxes to be provided for the weights of this machinery as well as for the weight of the apparatus revolving the lens; both boxes are to be carried below the first-story floor, so that the weight can descend to the level of the cellar floor.

The two floors of the light-house are to be constructed with timber joists placed 16 inches apart from centers, the first tier resting on the flanges of the wrought-iron framing-beams, the second tier on the flanges formed at the joint of the dwelling castings with the main-cornice castings. Both tiers of beams are to be stiffened by rows of cross-bridges. On these beams are to be laid the floors. The ontside walls of all the rooms and halls are to be lined with a double thickness of narrow tongued, grooved and beaded boards, with a layer of tarred roofing-paper between them; also the inclined inner roof surfaces; this lining to be nailed to pieces of furring, wedged tightly between the ribs of the iron-house inclosure and that of the roofs. The ceilings are to be lined with a single thickness of the same boarding.

The cellar and the watch-room windows to have metal sashes; the windows above, and the principal dormers, to have wooden sashes.

The cellar to contain two water-tanks, into which the rain-water is to be conducted. Overflow-pipes lead from the upper part of the same to the outside.

The lantern to have an iron parapet lined with wood, cast-iron lantern-posts, and a dome-shaped copper roof, terminating with a ventilator and pinnacle, which will form a lightning-rod.

The whole light-house being of metal, there is a continuous metal contact with the water.

The focal plane of this light-house is to be 46 feet 8 inches, and the gallery is to be 14 feet 7½ inches above the level of highest tides.

Details.

Top course of caisson.

The top course of the caisson will be set on the sections already completed and in place.

It is made in 24 castings, each 15 degrees in arc, 1 inch thick, with bottom and side flangs 1¼ inches thick; a horizontal flange on the inside, at the level of the under side of framing-beams, 1 inch thick; and a small flange on top, forming a rest for the drop-flange of the gallery-plate. The castings will be strengthened by vertical ribs, as shown on the drawings. The lower horizontal flange of this course will be joined to the top flange of the upper section, in place, by ninety-six (96) 1¼-inch bolts, each 4¾ inches long, four to each section. The holes for these bolts will be drilled after the work is set up at the place. The vertical flanges will be bolted together by eight 1¼-inch bolts each. Two of the castings will have openings for windows, with flanges, the inner ends of which will be faced. Eight of the castings will have seats for the corner brackets, four right and four

left, and eight other castings will have seats for the intermediate brackets, four right and four left. The top of the castings will be planed to receive the circular drop-flange of the gallery castings.

The contractor will have the option of making the castings which form the top of the cast-iron tube, either in a single tier or course of 7 feet 8 inches in height, or they may be divided into two courses of 3 feet 2 inches and 4 feet 6 inches, respectively. In the latter case the horizontal joint will be made at the bottom of the belt molding, with 1¼-inch horizontal flanges, and ninety-six 1¼-inch bolts.

As there may be a slight variation from a true circle in the present top of the cast-iron tube, the Engineer will furnish the contractor a templet giving the shape exactly. The new course must be made to suit.

Six mooring rings will be provided, made of wrought-iron, riveted to wrought-iron plates, which will be fastened to the caisson by four 1-inch bolts each, in such places as will be directed by the Engineer. Mooring rings.

The sashes for the two cellar windows, as shown in detail on plate 4, will be of cast-iron. All the outside suafaces will be planed. The glass will be held in place by bronze strips, fastened by 1¼-inch tap-screws. Part of the hinges will be fastened to the caisson castings by two ½-inch tap-bolts each, the other part of the hinge being cast to the sash; the holes for the pins, which are of steel, will be bored. The sash will be made water-tight by a continuous rubber band, and arranged to be drawn up close by means of two eye-bolts with thumbscrews. Cellar windows.

The sixteen brackets supporting the gallery will be of cast-iron. The eight larger brackets intersect each other at right angles; four will be full castings, the other four will be in two pieces each, which will be held together and to the full brackets by six ¾-inch bolts. The eight intermediate brackets will be cast with a boss for the railing-standards. Each of the brackets will be secured to the caisson by two 1½-inch bolts. All surfaces of contact of the brackets and the caisson castings and of the brackets with each other will be planed. Brackets.

The dwelling and the main gallery will be supported by a frame composed of No. 4 heavy 9-inch Phœnix beams and No. 13 6-inch Phœnix channel-irons. The beams will be of the following lengths: Rolled beams.

Two (2) 26 feet 9 inches long.

Two (2) 19 feet 7 inches long.

Four (4) 3 feet 6⅜ inches long.

There will be four pieces of channel-iron, each 19 feet 7 inches long.

Where the beams intersect they will be joined by angle-irons made of ½-inch boiler-plate held by ¾-inch bolts. One of the four angles of each intersection will be filled by a casting forming a boss for the railing-standard. Four of the connections of the beams with the channel-irons will be made by castings which serve as sockets for the boat-davits; they will be held to the beams and channel-irons by ⅞-inch bolts. The other four connections will be made by ½-inch boiler-plate bolted with ¾-inch bolts. The chan-

nel-irons will be held to the intermediate brackets by the bolt ends of the standards passing through the same. The beams will rest on the flange prepared on the caisson casting, which will be planed at the places where the beams rest. The openings left between the webs of the beams and the caisson will be filled with castings riveted to pieces of boiler-iron which are fastened to the beams by ½-inch bolts. The beams will be bolted to the cast-iron brackets.

Gallery plates.

The gallery will be made in 12 castings or plates, (shown on place 3,) the upper surface made rough with checkers. A rising flange will be provided on the inside and a molded nosing and drop-flange on the outside. On the under side, the plates will have a system of strengthening ribs, and a circular drop-flange planed to rest on the top flange of the caisson. They will be connected through side flanges by ⅝-inch bolts through the rising flange. Chipping pieces will be provided where the plates and their flanges rest on the beams and the channel-irons. All surfaces of contact not specified to be chipped must be planed. Plain margins will be left on the upper surface around the edges. Where the davits rest, a circular boss will be raised above the general surface, and where the braces are fastened through the plates and channel-irons, they will be provided with lugs underneath. Two of the plates will be provided with circular coal-holes with raised rims and cast-iron covers, which will be secured with chains to the flange below. One of the corner plates will be provided with chipping pieces for the attachment of the water-closet.

Gallery railing.

The gallery railing will be of wrought-iron. The lower ends of the standards pass through the flanges of the channel-irons and brackets and are secured to them by means of wrought iron nuts. The four interior angle standards will be fastened tothe angle castings. The standards will be square where the rails are attached, and will be drilled for the bolts holding the palms of the lower rail; a circular collar will be forged on the lower end where the standards fit on the gallery.

Holes are to be drilled in the rails to receive the ends of the stays; in the lower ends they will be countersunk. The stays are made of ½-inch round iron, reduced at the ends to ⅜-inch for riveting to the rails.

The upper rail has a rolled-iron cap, (No. 56 Phœnix pattern,) which will be riveted to it with ¼-inch countersunk rivets, one to each alternate space between the stays. The bar-iron of the upper rail will have scarfed joints, drilled to slip over the ends of the standards, to which they will be held by ornamental brass nuts set on square washers of cast-iron. At the water-closet the railing will be joined to the jamb and to the joint of the plates by bolts, and the corner standard will here be omitted.

Gates.

There will be two gates, made similar to the railing, hung on two wrought-iron self-acting hinges. They will have a diagonal brace of bar-iron, through which the round irons of the caging will pass. Stops will be provided for the gates, which will be locked by spring-latches riveted to the upright frame.

Ladders.

There will be two ladders from low-water level to the gallery, shown in the general plan, (plate 2,) and constructed as shown in detail, (plate 6.) The ladder-beams will be made of No. 15 Phœnix angle-iron; the ladder will be in two sections, united in the middle by wrought-iron hinges with steel pins, bolted to one pair of ladder-beams and riveted to the other pair. The upper part of the ladder will be held in place by two wrought-iron brackets bolted to the beams. The lower part of the upper half will be held in place by a frame of T-irons and tie-rods of the dimensions shown on the drawings, bolted to the caisson by eight ½-inch tap-bolts, and to the lower end of the ladder-beams by four similar bolts. The two cross-pieces at the joint will form a tread, and the other treads will be spaced from the same with 10 inches average rise. The treads to be of wrought-iron, roughened on the upper side. A hand-rail of round-iron will be fastened to the outer beam of each ladder and to the exterior standard of the gallery.

Three eyes will be provided to each ladder for the attachment of the hoisting-chain. Two will be riveted to the beams of the lower half, 6 inches from the end. The third will be riveted to the right beam of the upper half, 2 inches above the hinge, in order to hang the chain when the ladder is lowered.

Boat-davits.

There will be four wrought-iron boat-davits, of the form and dimensions shown. The pivot at the bottom will be turned. A collar will be forged on for the bearing of the braces to rest on; the portion above the same is to be turned. The braces will be made of No. 69 Phœnix iron, cut and shaped in the manner shown on the drawings, to be fastened with ⅝-inch bolts through the top flanges of the beams and channel-irons; above they will be fastened to the wrought-iron ring, which will be bored to fit the davit by two ⅝-inch tap-bolts. A cleat for fastening the rope will be formed by two pieces of round wrought-iron tapped into the ring. The upper part of the davit will be flat with a drilled hole, through which an eye-bolt will be passed. The nut will be secured with a pin.

Water-closet.

The water-closet will be located as shown on the general plan; (the details of construction are given on another plate.) The gallery-plate, on which it will be fastened, will be provided with raised surfaces for the reception of the foot-frame, made of 2 by 2 inches angle-iron, which will be held to the plate by ½-inch bolts. A plain saddle-strip will be cast on, to run across the door-opening and around the sides. Three openings will be provided in the plate for the rain-water to flow out. The mantel of the water-closet will be made of ⅓-inch sheet-iron, stiffened at the bottom by a wrought-iron strip ½-inch by 2 inches, and fastened by ⅜-inch rivets. A strip of the same dimensions will be riveted over the horizontal joint of the plates. A 2 by 2 inches angle-iron, bent in a circular form, will be riveted to the inside of the mantel, drilled and countersunk for six wood-screws to fasten the seat. Proper holes will be drilled in the foot-frame of angle-iron, for the fastenings of the risers, 2 inches apart,

which will be formed of narrow tongued and grooved boards. The door-jambs and lintel and the cornice will be of cast-iron, and the mantel will be riveted to the same by 3/8-inch rivets. The jambs will be connected with the gallery-plate and the lintel by 1/2-inch bolts, the surfaces of contact being planed. Two pairs of brass hinges will be provided, countersunk into and riveted to the jambs, to which the wooden door will be hung. The roof is made of two pieces of 1/8-inch sheet-iron; it is shown in development on the drawing; the joints are covered by strips of the same iron; the lower edges are riveted to the cornice. The pinnacle will be made of cast-iron, with a wrought-iron point terminating in a bolt with nutand washer to secure it to the roof. The gallery-railing on one side will butt against a strip 2 1/2 by 1/2 inch, which is riveted to the side of the water-closet; in front it will be fastened to the jambs by two 7-16-inch bolts. There will be two bulls-eye windows fastened to the mantel by tap-screws through circular strips, as shown on the drawings.

The castings which form the outside walls of the dwelling are shown in detail on plate 7. They will be 1/2-inch thick, with 3/4-inch joint flanges and strengthening ribs. The lower tier of castings will have a drip-flange near the lower edge, for the protection of their joints with the gallery-plates. All the horizontal and vertical joint-flanges and the face portion of the lower castings below the drip-flange will be planed, and the castings themselves will be held together by 3/4-inch bolts. The same size bolts will be used to connect the castings with the wrought-iron beams. **Dwelling castings.**

The location of the windows in the lower story is shown on the general plan. There will be two large and four small windows, all shown in detail. Each window will be formed of a sill casting, two jambs, a lintel casting, and two sash-boxes. The sill castings will be provided with ribs, joint, and drip-flanges similar to those in the dwelling castings, they will be bolted to the latter and to the rolled beams. On the upper flange provision will be made for the attachment of the jambs and boxes, which will be held down by bolts, as shown on the drawings. The jambs are shown on the same plate; they will be bolted by 3/4-inch bolts to the dwelling castings. They will have upper and lower flanges for the attachment of the sill and lintel castings. The box castings will be bolted to the jambs by four 7-16-inch countersunk tap-bolts each. The boxes will be planed on the faces on which the sashes run; the parting strip will be fastened into a groove, cut for that purpose in the face of the jambs, with tap-screws. In the interior of the box there will be a division of 1/8-inch sheet-iron fastened to flanges above and below with 1/4-inch tap-screws. The box will be closed on the inside by a cast-iron cover secured by eight 1/4-inch tap-screws. This cover projects 5/8 inch and forms a stop for the inner sash. **Window castings.**

The sashes will be of wood, and will not be furnished by the contractor for the iron-work, but he will provide and set in the frames two pairs of brass-axle pulleys. The lintel castings will, like the sill castings, form part

of the house inclosure, and will be provided with flanges and ribs; they will be bolted to the jambs, boxes, adjoining-house castings, and the architrave above.

All surfaces of contact between the different parts of the window pieces and the adjoining castings will be planed.

The entrance door piece to dwelling will be composed of a sill piece, two jambs with base blocks, right and left, two brackets, and a lintel, as shown on plate 9. The sill will be cast with a wash, and will have at its ends level shoulders for the attachment of the jambs; on the under side it will have a flange, through which it will be bolted to the rolled-iron framing-beam by four ¾-inch bolts. The two jambs will be right and left, strengthened by ribs and bolted to the sill and lintel by two ¾-inch bolts each through ¾-inch end flanges. A rebate will be formed for the door to close against. Two pairs of brass butt-hinges will be fastened to the jambs by tap-screws; they will be sunk flush with the rebate face of the jambs. The base-blocks of the jambs will be secured to the jamb castings by four ¼-inch countersunk tap-screws each. The jambs will be bolted to the adjoining dwelling castings by ¾-inch bolts. The lintel casting will be bolted to each jamb by two ¾-inch bolts and to the architrave casting of the main cornice by four ¾-inch bolts. The upper part of the brackets will be cast on the lintel piece; the lower portion will be fastened to the upper by ½-inch standing bolts, and to the jamb castings by ½-inch countersunk tap-screws. All surfaces of contact between the different parts of the door piece and the adjoining castings will be planed, and joint faces of the brackets and base blocks will be chipped to secure a neat fit. Door castings.

The eight corners of the dwelling will be covered with paneled pilasters, which will be bolted to the dwelling castings by ⅜-inch countersunk bolts. The pilasters will have bases and molded caps. Corner pilasters.

The main cornice will be composed of sixteen castings which form a continuation of the dwelling castings, and to which will be bolted the gutter and brackets. The sixteen main pieces will be cast with architrave moldings, strengthening ribs, and side and bottom flanges, through which they will be bolted to each other and to the dwelling castings by ¾-inch bolts. A top flange will be provided for the attachment of the roof castings. The surfaces of contact will be planed. The upper moldings of the cornice will be cast in sixteen sections, and will be provided with center ribs and planed end-flanges, through which they will be connected to each other by ⅝-inch bolts; the ribs and flanges will have return-flanges cast to them, through which the castings will be fastened to the main cornice castings by ½-inch bolts. The level part or plancier will have openings left where the brackets occur, as shown on the drawings. On the flange over the large ogee-molding a chipping piece will be provided for the upper fillet which forms part of the gutter castings, to fit close to the same. The gutter will be composed of sixteen straight and eight angular castings, which will be connected together Main cornice.

through planed end flanges by ½-inch bolts. Two of the straight castings which are placed in front of the two opposite dormer windows facing east and west, will be provided with pockets for the down-spouts, as shown on the drawings; the pockets will be tapped for this purpose. A sieve will be fastened over each pocket, cut out of ¼-inch sheet-iron, perforated in the manner shown on the drawings, and secured to the gutter by two ¼-inch tap-screws each.

There will be two down-spouts, made of 2-inch gas pipe, Down-spouts. connected at the bends with the requisite couplings. They will be carried into the house along the ceiling of the first story and down into the tanks in the cellar. From these, overflow-pipes will lead to the outside through openings in the caisson castings.

There will be two water tanks in the cellar, which will be Water tanks. made of 3-16 inch boiler-iron, riveted and calked; near the bottom a brass cock of 1-inch bore will be secured. On the top a ⅛-inch sheet-iron cover will be provided for the man-hole.

There will be twenty-four cast-iron brackets, to support Brackets. the upper part of the cornice, of the form and dimensions shown on the drawings. They will be fastened to the main castings by two standing bolts and one countersunk bolt each. The brackets will be neatly fitted to the plancier and the frieze surfaces of the cornice.

The roof will have the form of a truncated pyramid, with Roof castings. four wide and four narrow faces. The wide faces will be composed of seven castings each, and a dormer, which forms the middle piece. The narrow sides will be composed of three pieces. The castings will be provided with flanges, through which they will be fastened together, to the main cornice below, and to the roof-cornice above, by ⅝-inch bolts. The angles will be provided with fascia surfaces raised above the roof surfaces, and horizontal fascias will be run on the upper castings. The outer faces of the roofs will have up and down ribs, as shown on the drawings. A drip will be formed on the lower castings to protect the joint of the gutter with the main-cornice castings.

The four large dormer windows will each be composed Dormer windows. of six castings, as shown on the drawings. The sill castings will be bolted to the main-cornice castings by four ⅝ inch bolts each. They will have drip-flanges to correspond with those of the lower-roof castings. The upper surface will be inclined outward in the window opening, and level where the jambs and boxes will be attached; on the back there will be a molding, the upper part of which will form the inner stop-bead for the sash. The two jambs will be set plumb on the sill, cast with a reveal and flange on the window side, and with a return face against the roof surface, a small portion of the latter being formed of these castings, requisite flanges to attach to the roof castings being provided. The lower portion will be ogee-shaped, with raised ornamental knob and sunk ornaments on the front surface. Each jamb will have a strengthening rib in the middle, and top and

bottom flanges, through which it will be bolted to the sill and lintel castings by ⅝-inch bolts. The two box castings for the sashes will be similar to those in the first-story windows in every particular except the lengths. They will be square-headed; the circular part of the dormer will be formed on the reveal and outer return flange only, which do not form part of the box castings. The tinted casting will be of the shape and dimensions shown, (Plate 11.) It will be semicircular in the window opening, and on the front face there will be two raised knobs and sunk lines and ornaments. It will be stiffened on the inside by ribs, and will be bolted to the jambs and the adjoining roof castings by ⅝-inch bolts, as shown on the drawings. The roof will be strengthened with a rib on which bosses will be cast, which will be drilled for one of the dormers for the uprights of the fog-bell frame to pass through. All the surfaces of contact in the joints will be planed.

The fog-bell will be supported on a wrought-iron frame. **Fog-bell.** The uprights will be 1 inch in diameter, with round shoulders, screws and nuts on both ends. There will be two braces, 2 inches by ½, to slip over the uprights and to bolt through a palm against the roof. The yoke for the bell will be adapted to the shape of the latter. The roof casting above the dormer which carries the fog-bell will be cut through in the manner shown on the drawings, to allow the hammer to strike the bell, and the opening will be protected by a hood of sheet-iron, which will be held to the roof by ¼-inch bolts through a strip of ⅜-inch iron.

The small circular dormers will have their necks cast on **Small dormers.** the middle casting of the upper tier, with a circular return flange, through which the face-frame will be bolted. The face of this flange will be planed. The face-frame is shown in detail, (Plate 9); it will be bolted to the neck-flange by six ½-inch bolts, the surface of contact with the latter being planed. The keystone ornament on top will be fastened by a tap-bolt from behind with a countersunk head. There will be a circular sash cast with part of a hinge on top; the remainder of the hinge will be cast to the frame, the pin to be inserted from the interior of the dormer, as shown on the drawings. The closing surfaces of the frame and sash will be turned; the glass will be held in the rebate by a circular bronze strip, fastened by six ¼-inch tap-screws. A brass latch will fasten the sash on the inside, and a wrought-iron rod, hinged to a plate will be provided to keep the window open; the plate will be bolted to the frame by two countersunk tap-screws. The nut of the standing bolt securing the latch will have a conical opening for the reception of the end of the rod.

Two of the top castings of the narrow sides will be pro- **Smoke-pipes.** vided with collars for the passage of the smoke-pipes. The latter will be made of copper, and will be held near the roof-cornice by a brace and collar made of ⅜ by ¼-inch flat iron, bolted through palms to the cornice.

The roof will be surmounted by a molded cornice, and **Roof-cornice.** composed of eight castings. They will be provided with strengthening ribs and joint-flanges, which will be planed, and through which they will

be bolted together by ⅝-inch bolts. There will be another horizontal flange, through which the railing-standards will be secured.

The lanter-floor plate is composed of four castings. It will be strengthened on the under side by a system of ribs, and will be planed on the flanges, through which they will be bolted together by ⅝-inch bolts. The top surface will be roughened with diamond checkers sunk $\frac{1}{16}$ inch deep. Chipping pieces will be provided for the octagon parapet; the center of the floor-plate will have a plain circular surface, raised one inch, for the adjustment of the lens-pedestal. One of the castings will have an opening for a trap-door, which will close into a rebate. The door will be made of ¼-inch boiler-iron; the hinges will be of wrought-iron, of the shape shown on the drawings, fastened to the floor-plate by ⅜-inch countersunk bolts, and riveted to the trap-door. Wrought-iron lifting-handles will be riveted to both sides of the door. Lantern-floor plate.

Bosses will be raised on the floor-plate, through which the railing standards pass; the holes will be drilled. The wrought-iron standards will have screw-threads and nuts at their lower ends where they fasten to the roof-cornice, as described above. There will be circular collars forged on where they set on the bosses; above they will be finished square up to the shoulder, where the bottom rail is fitted. This rail will be made of ½ by 2-inch flat iron, and slips over the standard-bolts; they will be halved together on the posts. The standards will have a piece of gas-pipe fitted over the same between the lower and upper rails, and will have a shoulder for the upper rail, which will be slipped over and will be halved together in the same manner as the lower rail. The upper parts of the standards will have a screw-thread for the ornamental brass-nuts; cast-iron washers, of the shape shown on the drawings, will be set under them. Gallery-railing.

Lantern.

The lantern with its details is shown on Plate 13.

The parapet will be made in eight castings, one of which will be used for a door-frame. They will be provided with bottom flanges, through which they will be bolted to the lantern-floor plate by four ½-inch bolts each. They will be bolted together through side flanges by bolts of same size; the joint faces of the flanges will be planed. The top flanges will have shoulders for the attachment of the lantern-posts, and rebates will be formed for the insertion of the glass; the rebates and the shoulders will be planed. Four of the sections will be provided with air-registers made of cast iron, of the form and dimensions shown in detail; they will be secured in place by four ⅜-inch tap-bolts each. The revolving disk with handle will be of brass, neatly finished. Parapet.

The door will be of cast-iron, hung with two pairs of wrought-iron hinges. A number of holes will be bored and countersunk for the fastening of the wooden lining.

The door-catch will be of brass and of the size and shape shown in the

drawing; it will have its bolt slide in brass sockets, with a strong brass-wire spring around the tail of the same.

The handles will be of brass, with square steel shanks.

The eight lantern-posts will be of cast-iron, with square double flanges at top and bottom, for the attachment to the parapet and the cornice by two ¾-inch bolts each. Lantern-posts.

The surfaces of contact will be planed as well as the rebate faces for the glass.

The glass stops will be made of finished bronze; they will be flat bars beveled for the sills and soffits, and round for the lantern-posts. They will be fastened with ¼-inch bronze tap-bolts. Glass stops.

The cast-iron cornice will be in eight pieces. The joints will be in the middle of the sides, with planed flanges, through which they will be bolted together by ½-inch bolts. In the corners there will be ribs for the attachments of the rafters. The soffit portion will be shaped exactly like the sill. The lantern-posts will be bolted to the same, and will be planed in the rebate and on the joint with the posts. Cornice.

The eight rafters will be of wrought-iron, of the shape shown on the drawings. They will be bolted to the angle flanges by three ½-inch bolts each. There will be two tiers of wrought-iron purline-strips, fastened to the rafters by palms and ⅜-inch bolts. The rafters will be bolted on top to the flanges of the cast-iron ventilator pipe by ½-inch bolts each. This pipe will be cut above and below for the insertion of a wrought-iron yoke, through which the pinnacle will be held. The pinnacle will be of wrought-iron, secured with a nut below; it will have a shoulder above, to rest on the upper yoke; the upper portion will be finished with a platinum point to serve as a lightning-conductor. Rafters, &c.

The lantern roof will be made of 1-16 inch copper, in eight sections; the joints over the rafters to be riveted through strips of 1-16 inch copper, and brazed. On top the roof will be bolted to the flange of the ventilator pipe, and to the purlines by ¼-inch brass tap-bolts, the heads of which will be brazed to the copper surface. The roof will be bolted to the cornice by ⅜-inch brass tap-bolts through a bronze strip, about 6 inches apart. The ventilator ball and neck will be made of 1-16 inch copper; the ball will be terminated with a brass collar brazed on the same, through which the pinnacle will pass, forming a cup, which will be filled with solder. Copper roof.

The interior of the lantern-roof from the ventilator-pipe to the soffit-flange of the cornice will be lined with 1-32 inch sheet-zinc, fastened to the rafters by ¼-inch tap-bolts 6 inches pitch, and to the ventilator pipe and soffit by ¼-inch tap-bolts, about the same pitch, through wrought-iron strips.

Inspection, etc.

All the metal-work must be put together at the wo. shop, and inspected and approved by the agent of the Light-House Board before it will be re-

ceived. All castings which are honey-combed or otherwise imperfect will be rejected.

All parts of the iron-work must be chisel-marked, according to a uniform system, and a set of drawings also marked to correspond.

All rust must be scraped off, and the iron to receive a coat of linseed oil, put on hot, before being painted. All the work must be well fitted together, and set up at the shop, either entire or by sections, before it is prepared for shipment.

After inspection the iron-work must be painted with two coats; the finished surfaces must be covered with a mixture of tallow and lead, and all the smaller parts, as bolts, nuts, &c., boxed for transportation.

The contractor must provide all the rivets, forges, bolts, nuts, &c., of whatsoever description, necessary to erect and complete the metal-work at the light-house. He will, if required, also furnish a sufficient number of skilled mechanics to assist in the final erection, the said mechanics to be under the pay and control of the Light-House Engineer.

Every facility must be afforded the engineer for inspecting the work during its progress, and no part will be received or paid for unless it is in strict accordance with the requirements of the specifications.

The contractor will be furnished with an extra set of drawings, upon which he will be required to mark the weight of each casting, forging, &c.

The contractor is not to take advantage of any omissions in details of specifications or drawings, but will be required to perform all work that may be necessary to make the job complete, whether specified or not. For details not sufficiently explained or understood he will be required to refer to the Light-House Engineer, the latter claiming the right to order any details to be provided, without additional cost to the Government, should it become evident that such details were originally intended, or that they will be essential to the proper construction of the work.

MUNICIPAL WORKS.

*For a Main Sewer.**

SPECIFICATION

FOR THE CONSTRUCTION OF THE SNYDER AVENUE MAIN SEWER, ON SNYDER AVENUE, FROM SIXTH STREET TO DELAWARE RIVER.

As Authorized by Ordinance, Approved November 1, 1875.

DEPARTMENT OF SURVEYS,
CITY OF PHILADELPHIA.

See pages 213, 230, 235, 259.

MATERIALS AND CONSTRUCTION.

Ordinary Excavation.

Length. No more than two hundred feet of trench shall be opened at any one time in advance of the completed sewer, unless by a written order for the distance therein specified.

Width. The trenches shall be one foot wider on each side than the greatest external horizontal width of the sewer intended to be laid in them, unless the nature of the ground necessitates a greater width, which shall be determined by the Chief Engineer and Surveyor. The bottom of the trenches shall be excavated to the exact form and size of the lower half of the sewer, if so required.

Foundations made secure. Where, in the opinion of the Chief Engineer and Surveyor, the foundation is not sufficiently compact or solid, the Contractor shall excavate the trench to such increased depth and width as may be ordered; he shall then bring it up to the required level and form, either with concrete or foundation masonry, as the Chief Engineer and Surveyor shall determine.

Shoring. The sides of the trenches shall be supported by suitable shoring and bracing, wherever there is danger from sliding in of earth, but no allowance will be made therefor.

Treacherous ground. When running sand, quicksand or other bad and treacherous ground is encountered, the work shall be carried on with the utmost vigor, and shall be proceeded with day and night, should the Chief Engineer and Surveyor so direct.

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* The following specifications for sewers were carefully compiled by Rudolph Hering, C. E., Assistant to the Chief Engineer of the City of Philadelphia, and are believed to be the most complete of their kind. They may be made to answer for any similar kinds of work.

Rock Excavation.

In rock excavation not less than fifty feet of trench shall be opened in advance of the sewer. Length.

The rock shall be taken out one foot below the grade of the outer curved bottom of the sewer, and the trench then filled up to the required level and shape with masonry or concrete, as may be ordered. Depth.

The trench shall be one foot wider on each side than the greatest external horizontal width of the sewer intended to be laid in it. From the same point upwards, the sides of the trench shall be sloped in the ratio of two inches horizontal to one foot vertical, and so continued until the trench has a width of twelve feet; thence to the surface the sides are to be carried up vertically with a width of twelve feet. In case the width of the sewer exceeds ten feet, the trench shall be excavated one foot wider on each side than the greatest width of the sewer, and the sides carried up vertically of that width to the surface. Width.

In all cases of blasting, the blast is to be carefully covered with heavy timber, and the surplus material excavated to be immediately removed from the ground. Blast protected and material removed.

Where a line of water or gas pipe intersects the trench, any rock excavation within five feet thereof shall be removed without blasting. Pipes Intersecting trenches.

Refilling.

After the sewer is built, the work shall be backed in and carefully packed and rammed with proper material, and with proper tools, or otherwise compacted to the approval of the Chief Engineer. Material well rammed in layers.

Any timber used for shoring or other purposes shall be drawn as the filling progresses. No allowance will be made for such timber. Drawing of timber. Should there be a deficiency of proper material for refilling, the Contractor will be required to furnish the same without extra charge. The trenches must be refilled to the height which previously existed, unless the Chief Engineer and Surveyor shall direct otherwise. Deficiency of material.

The material for refilling shall be good loam, sand, clean ashes or gravel, free from stones above four inches in diameter, and of those below that size in a proportion not exceeding one part stone to three parts of earth in any place. Should any clay be dug from the excavation, it shall be placed next to the arch of the sewer in refilling. Kind of material to be used.

As the trenches are filled in and the work completed, the Contractor shall grub and clear the surface wherever necessary, and cart away and remove all surplus material, without additional compensation, to localities not interfering with the regulations of the city, and shall leave all roads and places free, clear and in good order. Removal of surplus materials.

Embankment.

Where embankment is necessary to support the foundation of the sewer, or to cover or protect it in any way, it shall be made of Width and slopes.

the width and slopes as shown on the plan. The surface of the ground receiving the embankment shall be carefully cleared of all muck or unsuitable material of whatever nature. Ground to be cleared.

The embankment shall then be formed of good loam or gravel, free from all stones more than four inches in diameter, and of those below that size in a proportion not exceeding one part of stone to three parts of earth in any place. Kind of material.

If built to support the foundation of the sewer, the material is to be deposited in layers of not more than six inches in thickness; each layer to be separately compacted by heavy iron rollers, or where these cannot be used, by heavy paviors' rammers. No breaks, steps or irregularities in the distribution of the material or formation of the layers will be allowed, and the whole embankment is to be carried up evenly, so as to make a compact and solid foundation. Thickness of layers rolled or rammed.

The sewers must in all cases be covered at least three feet deep over the top with earth, as described above (16), and of the widths and slopes shown on the plan. Sewers to be covered.

Where the trenches do not furnish sufficient material of suitable quality, the Contractor shall procure and supply such deficiency without extra charge. Deficiency of material.

All manholes are to be similarly covered and protected for a thickness of at least three feet around the shaft at the top thereof. Manholes, etc. protected.

Brick Masonry.

None but the best quality of whole, sound, perfect-shaped bricks, burned hard entirely through, shall be used. Quality of bricks.

They are to be culled when delivered upon the ground, and all bats and imperfect bricks are to be immediately removed from the work. Culled.

All bricks are to be thoroughly wet by immersion immediately before laying. Wet by immersion.

Every third course must be laid fair and smooth by line. The courses are to be kept perfectly straight in the direction of the sewer and parallel with the rise of the same. Laid by line.

Every brick is required to be laid in a full and close joint of cement mortar, as described under Section VII, on its *beds, ends and sides, at one operation.* In no case is mortar to be slushed in afterwards. Full joints of mortar on all sides.

The work in all cases is to be well and thoroughly bonded, and if the manner is specified on the plans, it shall be done in close adherence to them. Bonds to be well and thorough.

All brick work, as it progresses, must be racked back in courses, unless a special permission be given for toothing. Courses racked back.

All inverts or bottom curves are to be worked from templets, accurately made according to the dimensions of the sewer, and correctly set according to grades furnished. Invert.

The arches or upper curves are to be formed upon strong and proper centres, and the crown is to be keyed with stretchers in full joints of mortar. The extrados of the upper arch is to be neatly plastered with cement mortar, at least one quarter of an inch thick. Arch.

The centres upon which the arches are formed must be made strong, and according to the sizes and shapes required. They shall be made at least ten feet long. Centres.

No centre shall be removed until the work upon it has well set, and the refilling of earth has progressed up to the crown of the arch. All centres must be struck and drawn with care, so as not to crack or injure the work. Drawing of centres

All fresh work must be protected from injury, and should the regular continuity of the arch or invert be destroyed at any time, either from irregular shrinkage or from the centres being improperly fixed, or from any other cause, the contractor must remove such portions and correct the irregularities in a satisfactory manner. Fresh work protected and injuries repaired.

Stone Masonry.

All stone masonry must be of the exact dimensions and character as shown on the plans of the work. Exact dimensions.

All stones must be of a good quality, hard, clean and free from seams and imperfections, of good bed and build, and of such general sizes as may be specified. Quality of stone.

The masonry must be laid true and by line, with the stones on their largest natural beds. Laid by line.

All stones are to be laid in full beds of cement mortar of the quality described under Section VII, and all joints are to be thoroughly filled with the same (not grouted). Full beds and joints of mortar.

The tops and sides of the walls are to be plastered well and evenly with cement mortar, when so ordered. Tops plastered.

No masonry is to be built on a concrete foundation before it has thoroughly set. Concrete foundation.

The backing shall be laid in courses with parallel beds and joints shaped nearly at right angles to the bed. It must be leveled up to the face stones with each course, and be well bonded by alternating headers and stretchers and by breaking joint. The average size of the stones shall be about that of the face-stones. Every one must have a firm and solid bearing, and the joints must be thoroughly filled with mortar before the courses are leveled up. Special care shall be taken to make all joints on the back surface of the wall secure and impervious to water. Backing.

All joints shall be cleaned and picked out to a depth of at least one-half inch back of the face of the stone work, and also be made wet immediately before being pointed. The mortar for pointing shall consist of three parts of the best hydraulic cement, two parts of clean, sharp and fine bar sand, and such addition of any coloring matter as may be or- Pointing.

dered; and it shall be mixed in small quantities, and only for immediate use. The mortar shall be pressed into the joints well and securely, and finished off in such a manner and with such tools as may be required.

Foundation masonry. Wherever required, extra large stones for foundations are to be furnished and laid. They must be perfectly sound and hard, with good flat beds, and of such general size as will be specified.

Regular coursed pitched ashlar. The stones shall be rock-faced ashlar, pitched to the proper lines, with face out of wind, and dressed true and parallel on beds, so as to lay not more than a three-eighths inch joint; the vertical joints to be square with face, extending back six inches. The courses are to have such rises as shown on the plans. Headers are to have at least one and one-half times the depth of course for length of face, and three times the same for length in the wall. Stretchers must have a length not less than that given on the plan and *at least* as much bed as rise, and there must be one header to every two stretchers. Courses should bond on those below in a distance generally not less than the depth of course and in no case less than eight inches. Projections on the face of any stone must not exceed one-eighth of its rise beyond the pitched lines.

Random coursed pitched ashlar. The stones shall be rock-faced ashlar, pitched and dressed well and true to parallel beds and perpendicular joints. The courses shall be horizontal and not less than eight inches in height. All stones are to be laid firmly and no spalls or levellers to be used in the face. Headers must have a sectional area parallel to their face of at least one square foot and a length of at least three feet; one header shall be used in every superficial yard of wall surface and all stones must be bonded thoroughly. Projections on the face of any stone must not exceed two inches beyond the pitched lines.

Hammer dressed masonry. In case it is required to have random coursed ashlar hammer dressed instead of pitched, the face of each stone shall be carefully dressed to a surface as nearly uniform as possible with well defined, sharp and close joints. Otherwise the same as regular coursed pitched ashlar.

Broken ashlar. The stones must be dressed and pitched well and properly that the face of each be a polygon of straight sides not to exceed six in number. The joints to be perpendicular to the face for at least three inches back. All stones must be laid on their largest beds as far as possible. Headers must have a sectional area of at least one square foot and be three feet in length; there must be one header in every superficial yard of wall surface to form a good and secure bond throughout. Projections on the face must not exceed three inches beyond the face line of the wall.

Rubble masonry. The average weight of the stones for rubble masonry shall be between 50 pounds and 500 pounds, as may be specified, according to the size of the sewer. They shall be well bonded; every stone must have a firm and solid bearing and the joints must be thoroughly filled with mortar.

The general sizes of the stones must be that of two-men stones. Each one must have a fair and even bearing, and all joints and crevices are to be thoroughly pinned, and wedged and the courses well bonded. Dry walls.

Coping stones, when required, are to be of granite, bluestone or other sound stone of approved quality. The shape and dimensions given are to be truly adhered to, and they shall be dressed and hammered in the manner and after the pattern required by the plans, with a smooth top surface and close joints. They must be well and truly laid to line and grade. Coping stones.

Arch and Ring stones are to be of Granite or other approved stone. The latter are to be cut, dressed and hammered in the manner and according to the shape and dimensions given in the plans. The Arch stones shall be cut and dressed to fill the entire depth, the thickness of courses shall not exceed their depth, and the length shall not be less than one and one-half feet, except where closing up the course. All stones must be dressed smoothly to the full depth of the arch on a plane in the line of radius. The beds and end joints must not exceed one-quarter of an inch. The upper curve or extrados must be thoroughly plastered with cement mortar and made smooth and even. Arch and Ring stones.

Mortar.

All mortar is to be composed of clean, sharp bar sand and hydraulic cement of the quality to be approved by the Chief Engineer and Surveyor, and mixed in the proportion of *two* parts of sand to *one* part of cement. A greater proportion of cement shall be used when required by the Chief Engineer and Surveyor. Ingredients, portion and quality.

The above proportions are to be made by measurement, and not by estimation. The mortar must be made in a box, or on a floor, and in no case on the ground. The ingredients must be throughly mixed in a dry state, and the proper amount of water added afterwards. Mixing.

No greater quantity of mortar is to be prepared than is required for immediate use. Any excess left over at night, or that has been standing over two hours, shall not be re-tempered or used in any way. Quantity to be mixed.

Every facility for inspecting and testing the cement shall be furnished by the Contractor. Facility for testing.

When the cement has been accepted, if not immediately used, it must be protected from the weather, *kept dry*, and never be placed upon the ground without blockings under the barrels. Cement protected.

Lime mortar shall not be used for any part of the work. No lime mortar.

Concrete.

All concrete is to be composed of one part of mortar, (made as described in the preceding section,) and two parts of clean stone, furnace slag or hard brick, free from dust or dirt, and Ingredients and proportions.

broken so as to pass in every way through a two-inch ring. All stones too large for this test must be thrown out.

The stone and mortar are to be *measured* (not estimated) in the given proportions, and mixed in a proper box or on a floor, and in no case upon the ground. **Measured and mixed on a floor.**

The proper quantity of stone shall be spread out evenly in a layer not to exceed six inches in depth, and sprinkled so as to slightly wet the surfaces of all the stones. Upon it shall be spread evenly the proper quantity of mortar, freshly made; the whole is then to be quickly and thoroughly mixed, until every stone is coated with mortar; water must be gradually added, by sprinkling, if necessary to obtain a better consistency. **Manner of mixing.**

Concrete is not to be mixed in larger quantities than is required for immediate use. Any excess that has been standing over two hours shall not be re-tempered or used in any way. **Quantity mixed.**

Concrete must be deposited in layers not to exceed nine inches in thickness, and settled into its place by slightly ramming, sufficiently to flush the mortar to the surface. **Deposited in layers.**

When a fresh layer is to be put on one which has set or partially set, the entire surface shall previously be made thoroughly wet. **Fresh layer on one which has set.**

When in place, all wheeling, working or walking on it must be prevented, until at least twelve hours after being deposited. **No working on fresh layers.**

All dusty or dirty stone is required to be screened or thoroughly washed before it can be used; otherwise it shall be rejected, and must be removed from the work. **Dirty stone.**

Piling.

Piles shall be furnished of good, sound timber, approved by the Engineer in charge. They shall not be less than eight inches in diameter at lesser end, and properly sharpened and shod, if required, and of such lengths as may be specified. The bark is to be taken off in all cases. **Quality and size.**

They shall be driven until each pile does not yield more than one-half inch under the blow of a hammer weighing two thousand pounds and falling fifteen feet. The tops are to be sawed or cut off truly and evenly to the grade furnished. **Depth to be driven to.**

When sheet-piling is required to remain, it shall be of good, sound plank of the dimensions ordered, tongued and grooved, if necessary, and driven with the ram to the required depth so as not to crack or split. No extra charge shall be made for sheet-piling. **Sheet-piling.**

Foundation Timber and Planking.

All timber for foundations shall be approved by the Engineer in charge, and be free from shakes or cracks, and of the required **Quality and size.**

dimensions. It must be well and securely laid, and in close conformity with the plans.

When placed upon piles, it shall be nailed to each one with good, seasoned oak or locust tree nails of specified sizes. If bolts are required, they shall be made of best wrought iron, of the size and character as shown in the plans. Nailed and bolted.

Foundation plank, when laid directly on the ground, which must be graded perfectly level and smooth to receive them, are to have a good and firm bearing throughout, and be closely jointed, cut and laid as shown on the plans. If several layers are required, the planks must be laid transversely, as shown on plan, with broken joints in all cases of at least six feet. Plank on platform.

The contractor is required to have a sufficient quantity of timber and plank constantly on hand for bracing, sheet-piling, fencing or shoring, in order to be used immediately in case of accident. Timber on hand.

Manholes.

Manholes shall be worked into the arch of the sewer of the size, form, thickness and in the manner as shown by the plans, and they must be carried up to the established grade. Location and dimensions.

Where foundations are necessary, they shall be of stone masonry laid in cement mortar, and commence at least twelve inches below the inner bottom of the sewer at that point. Foundation.

The brick-work is in all respects to be of the quality described under another section, and the manhole must be built from templets at top and bottom, with not less than eight lines to guide the work. The connection with the arch must be true and secure, and in the manner shown on the plan. The joints are to be neatly struck and pointed on the inside, and the outside of the manholes must be neatly plastered with cement mortar. Brick-work.

Wrought-iron rods of good quality of the size, length and shape required for steps, are to be built in where shown on the plan. Wrought iron steps.

Every manhole shall be fitted with a cast-iron head and cover, free from imperfections, thoroughly cleaned and in dimensions and weight according to the plan. Cast-iron head and cover.

Every manhole is to be fully and completely built and fitted with cover as the work progresses and as each is reached. To be built as work progresses.

Connections with Sewer.

All connections required to be made with branch, intercepting or discharging sewers, and with manholes or inlets, whether brick or pipe, are to be newly built, repaired or re-connected, as the case may require, as the work progresses, and without extra charge therefor. They must be made carefully and in a perfect manner; the bricks at the joining edge must be shaped smoothly to the proper curves, set securely and with a thorough bond. Connections to be made without extra charge.

Wherever ordered, bull's-eyes shall be built into the sewer, at the given elevation and slope. They shall be circular in shape, have a clear inside diameter of three feet, and a four-inch ring of brick extending entirely through the side of the sewer. Bull's-eyes.

A length of vitrified drain pipe of approved quality, six inches internal diameter for house connections, shall be built into the sewer on each side where required, and at such distances apart as designated on the plan, without extra charge. House connections.

They are to be built into the walls of the sewer, terminating at an angle of 45° (degrees) when so ordered, with and in the direction of the flow of the current, and at the given elevation and slope. Discharge at 45 degrees.

They must also be set so that their inner ends will not project within the inner surface of the sewer, and the bricks in the sewer wall must be fitted closely and securely around them. Ends not to project.

When the pipes are ordered to be laid at an angle different from a right-angle, the ends of the pipes must be trimmed to the same before being delivered on the work. Pipes trimmed to angle.

The ends of all sewers, pipes, bull's-eyes and spurs, must be securely closed with brick masonry, or approved stoneware covers when not immediately used, without extra charge. Ends of connections to be closed.

Where connections are made with sewers carrying water, special care must be taken that no part of the work is built under water. A flume or dam must be put in, and the new work kept dry until finished. New work kept dry at intersections.

General Conditions of Agreement.

Plans.

The sewers are to be built of the materials, sizes, and dimensions, with the connections and manholes, on the lines, at the depths, and in the manner shown on the plans filed at the Department of Surveys.

All dimensions, materials, lines and grades must be in full accordance with the plans. Work in accordance with plans.

All necessary bull's-eyes or spors for connection of branch sewers, and all pipes for house connections are to be built in the proposed sewers at the points indicated on the plan of the work, without extra charge therefor.

The Contractor will be furnished with a complete set of drawings or tracings, showing all the details and dimensions necessary to carry out the work. Dimensions given thereon in figures are to have the preference over the scale. Plans furnished.

The plans and specifications are intended to include whatever may be requisite to render the works complete, but should anything be accidentally omitted, the same shall be executed by the Contractor. Accidental omissions.

No deviations from the drawings or specifications will be Deviations.

allowed, unless a written direction shall previously have been given to the Contractor by the Chief Engineer and Surveyor.

The city of Philadelphia reserves the right to increase or diminish the gross length of the sewer, the number and length of piles, also, the quantities of foundation plank, timber and stone masonry, with corresponding excavation, which are contained within the limits of the plans, to the extent found necessary by the Chief Engineer and Surveyor. No allowance will be made in case of increase for any sum above the prices bid, nor in case of decrease for any real or supposed damage or loss of profit occasioned by such diminution. The time stipulated for the completion of the work will be proportionately increased or diminished. Variation of quantities.

The plans and a copy of these specifications are to be kept constantly at the work by the Contractor or his authorized foreman. Plans and specifications kept.

The Contractor shall employ the District Surveyor to give him the lines and grades for the construction of the work, and also for the making out of the assessment bills, on the line of the sewer. He is also required to preserve all stakes, bench-marks, etc., made or established on the line of work, until authorized to remove the same. District Surveyor.

Should any dispute arise between the Chief Engineer and Surveyor and the Contractor, as to the true meaning of the drawings or specifications in any point, the decision of the former shall be final and conclusive. Dispute as to true meaning of plans.

Execution of Work

The Contractor must strictly follow, without delay, all orders and instructions of the Chief Engineer and Surveyor, or his authorized Assistant, in the prosecution and completion of the work and every part thereof. Orders and instructions.

The Contractor shall have charge of and be responsible for the entire line of works until completion. Charge and responsibility.

He is required to give his personal attention to the faithful prosecution of the work, and not to sub-let or assign the same, but to keep it under his own control, and, in case of his absence, to have a duly qualified person to look after the works. Personal attention.

The work is to be prosecuted at and from as many different points, at such times, in such parts, and with such force as the Chief Engineer and Surveyor may, from time to time, during the progress of the work, determine. Prosecution of work.

During the progress and until the full completion of the whole work, the sewers, basins, etc., are to be kept thoroughly cleaned throughout and left clean. Work to be left clean.

The Contractor shall furnish all necessary facilities, should it be deemed advisable by the Chief Engineer, to make an examination of any work already completed. If the work is found defective in any respect, he shall defray all expenses of such examination and of satis- Examination of finished work.

factory reconstruction. If the work is found perfect, such expenses will be allowed for.

The Contractor shall begin work within ten days from the date of the notice given to that effect by the Chief Engineer and Surveyor, and he shall progress therewith so as to complete the same in the time specified in his proposal, which will be reckoned from the date of said notice. Time of commencement and completion.

No charge shall be made by the Contractor for hindrances or delay from any cause during the progress of any portion of the work embraced in the contract; but it may entitle him to an extension of time allowed for completing the work, sufficient to compensate for the detention, to be determined by the Chief Engineer and Surveyor: provided the Contractor shall give the Engineer in charge immediate notice, in writing, of the cause of the detention. Delays.

Materials and Labor.

The Contractor is to furnish all labor, materials, tools and plant necessary to execute the entire work in the best possible manner. Labor, materials, &c

He is further required to employ only competent and faithful laborers, and none but first-class mechanics, and whenever the Engineer in Charge shall inform him in writing that, in his opinion, any man on the work is unfit to perform his task, the Contractor must discharge the same from the work and not employ him again on it. Workmen.

The ground shall be excavated in open trenches to the necessary depth, and to the widths and lengths as specified elsewhere. Open trenches.

No tunnelling will be allowed except by written consent and in accordance with the directions of the Chief Engineer and Surveyor. Tunnelling.

The Contractor shall pump out or otherwise remove any water which may be found or shall accumulate in the trenches or other excavations, and shall form all dams or other works necessary to keep them entirely clear of water while the foundations are being laid and the masonry constructed. Trenches kept dry.

All the masonry throughout, whether of brick or stone, shall be laid in cement mortar, made and laid as described in these specifications. All masonry in cement mortar.

Mason-work of all kinds shall cease on the first day of December, unless the contractor is otherwise directed by a written notice, and then only for such time as may be designated; no work shall be resumed before the time appointed. Upon the suspension of mason-work, the same shall be well protected and the grounds left in good order, according to instructions given by the Chief Engineer and Surveyor. Mason-work to cease Dec. 1st.

All materials furnished and all work done which, in the opinion of the Chief Engineer and Surveyor, shall not be in accordance with this specification, shall be immediately removed, and other materials furnished and work done which shall be in accordance therewith. Unsatisfactory material and work.

The contractor, without a written permission from the Material for refilling

Engineer in charge, is required not to sell, remove or permit to be removed from the line of the work, before the trench shall have been refilled, any sand, gravel or earth excavated therefrom which may be suitable and required for refilling.

All sewers, culverts, drains or basins rendered unnecessary or becoming disused by the construction of the work herein contemplated, must be filled in and made good without extra charge. Filling in of old drains.

All material, etc, excavated from within the required limits of excavation shall be considered property of the contractor, excepting water, gas, and drain pipes, paving blocks, curbs and flagging, which, in case they are not required to be replaced, must be piled and left in such part of the street as may be directed. Property of contractor.

If any disputes or differences shall arise as to the efficiency of labor or quality of materials employed, they shall be settled by the Chief Engineer and Surveyor, whose decision shall be final and conclusive. Disputes as to quality of materials and labor.

Interference with Travel and Works.

All material excavated or delivered shall be placed where directed, so as to interfere as little as possible with travel; and unless special permission is granted to the contrary, footways shall be kept clear of earth for a width of three feet, for which purpose boards shall be set to hold the bank where needed. The contractor shall provide and maintain all necessary fences and bridge-ways, and shall prosecute his work so as not to interfere with or obstruct the running of street-cars, and no charges against the city or railway companies for extra cost on this account will be allowed. Travel.

The contractor shall place sufficient lights on or near the work, and keep them burning from twilight until sunrise, and provide watchmen on the work for the safety of the public, whenever deemed necessary by the Chief Engineer and Surveyor. Watchmen and lights.

The contractor is required to sling, shore up and secure in their places all water and gas pipes, without injury, and to provide for and maintain the flow of drainage and water-courses, whether on the surface or underground, which may be interrupted during and by the progress of the work. Where it becomes necessary to remove the pipes from their position, they shall be carefully cared for and replaced by the contractor, or at his own cost. Water and gas pipes drainage.

The carriage and foot-ways on the line of the work are to be regraded and repaved to the extent which the aforesaid work may render necessary. All curb, gutter, flag and paving-stones, which may have been displaced on account of the work, are required to be carefully reset. Should any of said stones have been broken in consequence of any act or omission of the contractor, new stones, to be approved by the Engineer in charge, shall be furnished and set in place thereof by the contractor at his own expense. Regarding repaving, etc.

The whole of the regrading and repaving, etc., must be done to the satisfaction of the Chief Engineer and Surveyor, and kept in good repair for a period of one year from the date of completion. Kept in repair.

All works of drainage intercepted or connected shall be restored and made good, and all surplus and offensive material shall immediately be removed from the drains. Underground work.

Damages and Penalties.

The contractor shall be responsible for all injury to water pipes, gas pipes or other structures met with in the prosecution of the work, and shall be liable for damages to public or private property resulting therefrom, which amounts may be deducted from any estimate due him. Damage to water and gas pipes.

In case of any accident, as aforesaid, the contractor shall give immediate notice to the proper authorities. Immediate notice.

The contractor shall assume all responsibility for loss, damage or injury to persons or property, arising out of the nature of the work, from the action of the elements or from any unforeseen or unusual difficulties. Damage to persons or property.

Should the sewer lead through private premises, the City of Philadelphia will pay the compensation for right of way, but no other damages. Private premises.

The contractor agrees to idemnify and save harmless the City of Philadelphia from all suits or actions of every name and description brought against it for or on account of any damages or injuries received or sustained by any party or parties by or from the contractor, his agents or servants, in the performance of the work under the agreement. The contractor further agrees that all or so much of the moneys due to him under this agreement as shall or may be considered necessary by the Chief Commissioner of Highways, shall or may be retained by him until all such suits or claims shall have been settled, and evidence to that effect furnished to his satisfaction. Suits and claims.

If any part of the street, sidewalk or curbing on the line of the same shall, in the opinion of the Chief Commisioner of Highways, require repairs within one year after the date of completion, the contractor shall, within three days from the date of notice given, make the necessary repairs; and if he neglects to comply with such notice, the Chief Commissioner of Highways may employ other men to make such repairs, and the cost thereof shall be paid by the contractor or his sureties. Repairs to street for one year.

The contractor or his sureties will be held liable for keeping in perfect repair and good order the whole of the *new* works to be constructed under the contract for *three years* after the date of completion. Sureties bound for three years.

If the Contractor shall abandon the work under this agreement, or if, at any time, the Chief Engineer and Surveyor Abandonment or delay.

shall be of the opinion, and shall so certify in writing to the Contractor and City Councils, that the work, or any part thereof, is unnecessarily delayed, or that the Contractor is wilfully violating any of the conditions or covenants of the contract, or executing the same in bad faith, then the contract shall become null and void, the security bonds forfeited, and the materials delivered at and built into the work shall be property of the City of Philadelphia.

Should the work under this agreement not be finished within the time specified, the Contractor shall forfeit a sum of twenty dollars for each and every day which shall elapse after the expired time to the date of completion.

Penalty for non-completion within specified time.

Payments.

Payments will be made to the Contractor in monthly instalments of eighty per cent. on the amount of work executed during the preceding month, under and in accordance with the provisions and stipulations of the contract, which will be certified to by the Chief Engineer and Surveyor.

Payment in monthly instalments.

Final and full payment of the balance due the Contractor, after all legal and equitable deductions, will be made upon the certificate of acceptance and approval of the Chief Engineer and Surveyor, one month after the date of completion, provided the whole work, and each of its parts, including the street, be in perfect order.

Final payment one month after completion.

The Contractor shall accept, as part payment of the amount of his contract, the assessment bills charged upon the properties in front of which the sewer shall be completed, as per Ordinance approved May 12th, 1866, and supplemented by Ordinance approved February 16th, 1869. He shall collect them at his own cost, and the better to enable him so to do, he may use the name of the City of Philadelphia, and employ all legal remedies or proceedings, whether of lien or otherwise, to which the said City may be competent.

Assessment bills.

The Contractor shall not be entitled to demand or receive payment for any work as extra work, unless ordered in writing by the Chief Engineer and Surveyor to do the same as such, and at a price fixed by him previously to its commencement.

Extra work.

SAMUEL L. SMEDLEY,

Chief Engineer and Surveyor.

Wilmington, Delaware, Water Works.

SPECIFICATIONS

FOR COMPLETING THE COOL SPRING RESERVOIR.

See page 262.

OFFICE OF BOARD OF WATER COMMISSIONERS,
WILMINGTON, DEL., June 25th, 1877.

Section 1. The contractor shall take the reservoir as it now stands, and begin by excavating so much of that portion of the middle bank known as the overflow, as may be required. This excavation shall be made by carrying down the present slopes of the ends of the overflow to a depth of 14½ feet from the present surface of overflow, and will comprise about 1452 cubic yards. After this excavation is no longer needed as a passage way, it shall be puddled up as hereafter specified to the general level of middle bank, dove-tailing or off-setting the ends into the banks to a depth at right angles to slope of not less than 6 feet; this puddling will comprise 1600 cubic yards. Such clay for puddling as may be approved by the Engineer, shall be used; it shall be free from roots, sods, stones or other injurious material. Shall be placed on in layers of not over 4 inches in depth, shall be solidly rammed, the surface of each layer being broken up as specified in section 5, before another layer is deposited, and the whole completed to the satisfaction of the Engineer, and in accordance with the lines and levels as given by him. The work upon the South Basin shall not be commenced until such time as may be directed by the Commissioners, with such changes in the terms of the specifications, or addition to or alteration in the character or quantity of material as may be deemed expedient, or the contract may become null and void, at the discretion of said Commissioners, upon the completion of the North Basin.

Section 2. The roadway leading into the North Basin shall be taken out as soon as the overflow shall have been excavated, and the slope and bottom now covered by said roadway be prepared to receive the clay puddling and brick lining, by bringing the same to a proper grade, removing all stones or rocks which may protrude from the bottom or face of slope, and by excavating a ditch at the foot of slope, which shall be not less than 2½ feet deep from rough bottom, 6 feet wide and not over 100 feet long; said ditch to be filled with puddled clay, prepared, deposited, and rammed as specified in section 5. The material from said roadway shall be deposited at such point within the reservoir grounds as may be designated by the Engineer.

Section 3. All weeds and grass shall be pulled up, and, together with stones, be removed from bottom and slopes. The unpuddled portion of the bottom of the North Basin shall be brought to its proper grade, the waste material being removed to such point within the grounds as may be designated by the Engineer.

Section 4. So much of the upper surface of the puddle now in place, which has been injured by frost or exposure, amounting to about one thousand cubic yards, shall be taken off and removed entirely from Basin, or used in connection with other material as puddling, at the discretion of the Engineer.

Section 5. The whole bottom of the North Basin shall be covered with such quality of clay-puddling as may be approved by the Board of Water Commissioners, to a depth of 24 inches, from rough bottom, including therein such portions of the bottom already puddled, as may be approved by the Engineer. The sides or slopes shall be lined with the same quality of clay as that above mentioned, and at the bottom shall have a depth of 24 inches, measured at right angles to the slope, and shall taper to a depth of 20 inches at the top, measured at right angles to slope. The clay shall be put on in horizontal courses or layers, not exceeding 2 inches in thickness, and must be ground in a mill suitable for the purpose, unless otherwise directed by the Engineer, before being delivered at the reservoir, and all surface soil, sods, roots and stones shall be carefully excluded. The excavation and preparation of the clay shall be made under the direction and superintendence of an agent appointed by the Board of Water Commissioners. The clay shall be thoroughly incorporated with the existing banks; shall be rolled on bottom and rammed on slopes, to such a degree of solidity as may be required by the Engineer; and the surface of each layer shall be sufficiently broken up by picking or otherwise, so as to insure a thorough incorporation of the succeeding layer with it; the clay shall be moistened sufficiently to puddle properly, and after having been so packed or puddled, shall be kept constantly moist till protected by bricks or gravel. After the clay-puddling has been put on as specified above, it shall be accurately dressed and graded to the slopes, curves and other lines; shall be perfectly solid and free from cracks or other defects, and in every respect be properly prepared to receive the coating of gravel or brick.

Section 6. The bottom of the basin shall be covered to the depth of 4 inches with good clean gravel, which shall be freed from all stone of over ½ an inch in diameter, by screening, and shall be such as may be approved by the Engineer, and be rolled or otherwise consolidated.

Section 7. The bottom of the basin shall be paved, except as specified in section 8, with the best hard burned brick, which shall be straight and smooth and of uniform size and quality, laid flat, in sufficient clean sand to properly seat them, and shall be covered with sufficient clean white sand to completely fill in the spaces between the bricks, said white sand to be brushed or broomed into the joints in the usual manner.

Section 8. At the entrance of the main pipe into the basin, a flagging shall be laid in cement; flag stones of not less than 6 inches thick, 9 feet long and 2 feet wide, accurately dressed and faced, and to conform in all respects to the stone used as coping on the walls around the reservoir shall be used, laid flat and well bedded in hydraulic cement, covering a space of

9 feet wide and twelve feet long. At the point where the communicating pipe enters the basin, a space 6 feet wide and nine feet long shall be covered with stones of the dimensions, and laid in the manner, specified above.

Section 9. The sides or slopes of the basin shall be covered with same quality of brick as above specified, laid in hydraulic cement mortar, made of one part of the best Rosendale cement, or any other which may be approved by the Engineer, and one part clean, sharp, river sand, mixed only in such quantities as can be used immediately, and kept stirred until so used; the bricks shall be laid on edge, one over the other, in two courses, so as to form a 9 inch wall and in such a manner that all joints shall be broken; no ties nor headers shall be used in its construction, and the joints shall be carefully pointed as the work progresses. Each brick shall be dipped into water before being laid, and the face of the wall shall be kept wet from the time it is begun till one week after it is finished. The wall or lining shall be finished at top in such a manner as will fit it to receive a stone coping.

Section 10. Any of the conditions and specifications herein given may be changed or modified by the Engineer to meet any unforeseen contingency, or as may be suggested by the interests of the City, or as circumstances may require; if they increase the cost of the work, shall be subject to section 11, and if they decrease the cost, such decrease shall be in proportion to the rates paid for similar work.

Section 11. No claim or bill for extra work shall be allowed or paid, unless said work has been done by special written agreement with the Engineer, ratified by the Board of Water Commissioners, entered into prior to the commencement of such work.

Section 12. All the work shall conform with such lines, levels, depths, slopes, curves and circles, or with such dimensions and shapes as may be directed by the Engineer. All stakes, lines, levels, &c., shall be given by or at the direction of the Engineer.

Section 13. All the different portions of the work shall be done in the order designated by the Engineer, and all the work herein specified and contemplated, or found necessary, shall be done in accordance with his orders and directions, and he shall be the judge of the quality and fitness of all the machinery used in the work.

Section 14. On the completion of the Basin, all surplus materials, earth and rubbish of every kind, shall be disposed of within the reservoir grounds as directed by the engineer, and all structures, implements, &c., shall be removed from said grounds as may, at the time, be directed.

Section 15. All labor, tools, appliances and appurtenances of whatsoever kind, required to do the work in proper and satisfactory manner, shall be furnished by the contractor.

The contractor, however, can have the use of the six heavy Rollers now in the basin, on condition that he returns them to the Commissioners when the work is completed, in the same perfect condition they are now in.

Water for puddling and mortar can be had from the city main on the Franklin Street bank of the basin at Eleventh Street.

Section 16. The contractor shall, when required to do so by the engineer, remove from the work any superintendent, workman, or other person employed on said work, who shall refuse or neglect to obey the instructions of the engineer or his agent in anything relating to the work, or who shall perform his work in any manner contrary to the specifications or directions of the engineer, or who shall be deemed by him incompetent or unfaithful.

The contractor shall also, on the demand of the engineer, discharge from the work on the basin any drunken, disorderly, insolent, or otherwise disagreeable person, and shall not again employ him on the work without the consent of the engineer.

Section 17. All measurements and estimates of gravel, brick and flagging shall be made after the above mentioned materials have been put in place in the basin; the clay for puddling shall be measured in excavation after the top soil or other objectionable material has been removed.

Section 18. In the absence of the engineer, any person he, or the Board of Water Commissioners may designate as having charge of the work or any part thereof, shall have and exercise all the powers of said Engineer, in all matters relating to the execution of the work herein specified, and the orders of said person shall be fully observed and obeyed.

Section 19. The engineer shall furnish monthly estimates to the Board of Water Commissioners of the amount or quantity of work to be paid for, and of all such work as may have been done during the preceding month.

Section 20. In case of the refusal or neglect of the contractor to remedy and make good any defect in the work, within the time required, such work may be done by order of the Board of Water Commissioners, and its cost deducted from any amount due or to become due the contractor.

Section 21. No part of the work shall be assigned or sub-let to any person or persons, without the consent of the Board of Water Commissioners, and if any part is so assigned or sub-let, it shall not in any wise affect the conditions or provisions of these specifications.

Section 22. None of the work shall be considered as accepted, which may be found defective in its construction or execution, before the final acceptance of the whole work.

Section 23. Should the contractor fail to deliver any material, or do any work at the time required by the engineer, the latter may order the same done, and have the cost thereof deducted from any amount due or to become due the contractor.

Section 24. If the engineer shall certify, in writing, to the Board of Water Commissioners, that the work is unreasonably delayed, or any of the conditions of the agreement or specifications are violated, the said Commissioners shall have full power to annul the contract or agreement, and after notice in writing to the contractor to this effect, it shall, thereupon, become null and void and of no binding effect.

Section 25. The engineer shall define the meaning and intent of the specifications herein contained, and his decision shall be final.

Section 26. Wherever the word "contractor" is used, it refers to and designates the party who enters into an agreement to execute and perform the work as herein specified and contemplated, or the legal representatives of said party.

Section 27. Wherever the term Commissioners or Board of Water Commissioners is used, it refers to and designates the persons declared to be Commissioners for the purpose of completing the Cool Spring Reservoir, chapter 440, vol. 15, part 2, Laws of Delaware, passed at Dover, March 20th, 1877.

Section 28. Whenever the word engineer is used, it refers to and designates the person who shall act as constructing and superintending engineer in the construction and completion of the Cool Spring Reservoir, in the city of Wilmington, Delaware, under the direction of the Board of Water Commissioners.

Section 29. The South Basin shall be completed in accordance with the above specifications, except in regard to the time mentioned for completion of the North Basin, unless said specifications be changed, &c., as stated in section 1.

Section 30. The contract must be signed within three (3) days after the award of the work, and the work must be commenced by the contractor within five (5) days after notice of said award has been given said contractor by the Board of Water Commissioners, and the whole work necessary for the completion of the North Basin shall be finished on or before November 1st, 1877.

Section 31. Proposals must be made for each Basin separately, also, for a specific or total amount of the whole work complete, and bidders must name the price they offer to do work or furnish material for, in writing, as well as in figures. The Board of Water Commissioners reserve the right to reject any or all bids.

Section 32. Each bid must be guaranteed by two responsible men, known or properly vouched for to the Commissioners, and whose signatures must be appended to the guarantee.

Section 33. The contractor shall give such security for the faithful performance of the contract as may be required by the Board of Water Commissioners.

Section 34. Cash payments will be made monthly, payable on the 25th day of each month, of eighty-five (85) per cent. of all estimates or bills approved by the Board of Water Commissioners, for work done or materials furnished, during the preceding month, and the balance of fifteen (15) per cent. will be paid in cash upon the satisfactory completion of the contract, and the engineer's approval of the work and its acceptance by the Board of Water Commissioners.

Section 35. The following are the estimated quantities and material required for the completion of the North Basin.—

8,400 Cubic Yards Puddling.
1,200 " " Gravel.
670 " " Sand.
3,000 Bbls. of Cement.
1,200,000 Bricks.
81 Lineal feet of Flagging.

The following are the estimated quantities and material required for the South Basin:—

1,200 Cubic Yards Puddling.
1,400 " " Gravel.
670 " " Sand.
3,356 Bbls. Cement.
1,326,000 Bricks.
81 Lineal feet of Flagging.

Section 36. The foregoing quantities and materials have been estimated approximately, and parties proposing to bid are requested to examine the Reservoir in its present condition, and judge for themselves as to the character of the work, cost and quantities of clay, gravel, brick, cement, sand, and other materials, and of all the details and circumstances affecting the cost of the work.

Section 37. Bidders for this work are informed that it is the intention of the Board of Water Commissioners to have the work herein specified performed in the best manner possible, and of the very best materials, and that they will be rigidly held to an absolute performance of each portion of the specifications.

Section 38. Proposals must be sealed, and marked, "Proposals for completing the Cool Spring Reservoir," and must be addressed to the Board of Water Commissioners, and will be received at the office of JOHN P. ALLMOND, corner of Market and Eighth Streets, Wilmington, Delaware, until 3 o'clock P. M. on Tuesday, the 10th day of July, 1877.

Signed,

JOHN P. ALLMOND,
JAMES BRADFORD,
CAESAR A. RODNEY.
Commissioners.

MAJOR S. CANBY,
Resident Engineer.

M. C. CONWELL,
Consulting Engineer.

N. B.—These Specifications for Wilmington Water Works were prepared by Isaac S. Cassin, C. E.

ARCHITECTURAL.

For the Construction of a College Building.

SPECIFICATIONS

FOR A COLLEGE BUILDING FOR THE UNIVERSITY OF PENNSYLVANIA, AT THIRTY-FOURTH AND LOCUST STREETS.

See page 267.

Workmanship and Inspector.

Each part of the Building to be completed in a good workman-like manner to the full intent and meaning of these specifications and the drawings, and details hereafter to be furnished in explanation of these drawings, to the entire satisfaction of the Building Committee or their Architect:—who shall have full power to refuse any material different from those described to be used, and to cause any unsound work to be taken down at the Contractor's expense.

Material not mentioned but necessary

Any work or material necessary for the proper construction of the Building, or deemed by the Architect essential to properly carry out the plans—even though not specially mentioned, but evident from the nature of the case, to be done by the Contractor, without extra charge for the same.

Alterations, if any.

If any alterations should be made in the drawings, or any change of construction, or difference of material, other than expressed by the plans and specifications; the cost of such changes or alterations, to be determined upon before being made, and agreed upon in writing, otherwise no charge for the same to be allowed.

Variations from contract price.

Should such change or alteration cost *less* than the work as originally agreed upon, the difference in amount to be deducted; if *more*, the difference in amount to be paid to the Contractor.

Heights of the Stories.

Cellar.

The Building has a cellar 9 feet high in the clear, under Assembly, Corridor, Stairways and S. E. Room, and under Janitor's Room.

Basement, 1st, 2nd, 3d and 4th stories.

Basement 14 feet, First Story 15 feet, Second Story 14 feet 6 inches, Third Story wings 14 feet, Third Story rear centre 16 feet, Chapel 28 feet, and Fourth Story Centre Building 16 feet, all in the clear of floor and ceiling.

Dimensions.

The various dimensions of the Building, and sizes of the different rooms, are figured on the plans.

Excavation.

Trenches.

The trenches to be excavated to a sufficient depth to allow for secure foundation. They will be arranged according to grades of the lot; to be one foot below present surface of ground. Any additional depth

required for a good foundation to be extra; and to be done by Contractor for the sum of 30 cents per cubic yard.

The space under Corridor from east to west the entire length of the Building to be 7 feet 6 inches deep, or deeper if the surface is lower, below top of Basement floor, for cold air duct or passage way. Space under Corridor, &c.

Trenches for foundations of outside wall must in all cases be 4 feet below surface of ground when graded. Depth can be measured from elevations at different points.—Trenches for footings of all bearing walls, must be not less than 1 foot below the lowest level adjoining them, or as much further as may be necessary to insure perfect solidity. —Trenches for foundation of Corridor Walls to be 1 foot below surface of ground in cellar. Trenches for foundations of outside walls.

Drain Pipe in air duct to be at least 2 feet below ground at highest part. Drain Pipe.

Excavations to be made for all drain pipes, air ducts, water and gas connections, where required.

The ground forming the beds of trenches, for all foundation walls, to be beat down, and when the walls are in, the earth to be well rammed down, in the spaces on each side of them. Beds of Trenches.

All foundation trenches below grade, to be sufficiently wide to allow for making a two-faced wall. Foundation Trenches.

The surplus earth to be deposited around the Building, and graded as required.

The portions arranged for Cellars are under the S. E. Room, the Library extension in centre of rear, the Corridor from east to west, space under Janitor's room, and the Stairway bays. All the remainder to be filled within two inches of the level of the Basement floor—to be afterwards covered with Asphalt Pavement. Cellars.

Stonework.

All foundation walls to be built of best quality hard building stone, such as Leiperville or Fairmount Stone:—All footings to measure at least 6 inches wider than the wall above it. Foundation Stone.

First course of foundation of outside walls to be of three-men or through stone, laid on thick bed of mortar or concrete laid in the trenches. Concrete.

Second course of two-men stone, and the remainder to the first floor, of large stone, laid on their broadest beds, and hammered down solid.

Basement walls to top of first floor, where exposed, to be faced with Leiperville Gray Stone; to be large stone and laid broken range rock work, capped with water table course of Hummelstown Brown Stone, around the entire Building as per detail, projecting beyond Basement Walls—(8 inches by 12 inches.) Leiperville Stone. Hummelstown Brown Stone.

Sills of doors and windows to be square droved; jambs, arches or other heads of openings, to be of Leiperville Stone, and finished from the point.

All exterior walls above Basement to be faced with Serpentine Marble; to be laid broken range work, finished from the point for the entire Building. All stone to be large and flat, well bonded and bedded and hammered down solid, and in no case to be built more than 10 feet high until the mortar is well set. Serpentine. The Walls.

All wall Cornices, Cappings of Buttresses, and Gables, sill and belt courses and arches to be of Ohio Stone, in form and style to conform to the elevation and detail drawings, hereafter to be furnished. Cut stone joints. Cornices. Cappings. Ohio Stone.

Arches of windows and doors, to be drafted and pointed. Jambs square and chamfered, 8-inch reveal, Corridor windows, 12-inch reveal, to be pointed with the tool. Corners and buttresses pointed. Window sills, buttresses and gable cappings to be square droved. Jambs.

All string courses between window sills, &c. to be drafted and pointed. String Courses.

All interior walls in Cellar, and backing of exterior walls, to be of good hard common quarry building stone, laid on their broadest beds, well bonded and hammered down solid, and bedded in good gravel mortar. Interior Walls.

All walls tinted gray on plans are stone of various thicknesses which are figured.

Front porch to be built as per design, and detail drawings to be furnished. To be tool dressed work, with polished Scotch granite columns, and carved Ohio stone caps. Body of porch to be of gray stone from the Franklin quarries. Base course of brown stone. All the steps to be of granite. Front Porch

Floor of porch to be laid with rubbed blue flag, with one red stone in centre. The floor of water closet rooms in basement to be laid with flag stone 2 inches thick. Floor of Porch.

All work exposed, to be properly pointed with tinted Portland cement, as directed. All joints to be thoroughly raked out before pointing. All area walls to be capped with flag. Slate hearth to be furnished for the grate. Strips, plugs, blocks, scantling, &c., to be built in walls, where required, for nailing stripping grounds or wood work. Pointing.

Especial care to be taken with all walls and piers supporting columns. All angles to be kept plumb and true. Cellar stone walls to be smoothly dashed and broomed. Large stones to be placed under all girders, beams, &c., where required. Walls and Piers.

The tiling of vestibule to be white Italian marble, laid in squares diagonally with border as per plan; to have 10-inch skirting moulded edge of marble. Tiling of Vestibule. Skirting.

The stone mason must furnish, erect, and remove all scaffolding necessary for his work, and must put up from time to time, as the work progresses,

shields of boards to protect the work when it is done, from damage, and be responsible and required to repair any injury that may be done by neglect of this precaution. Cold air flues and gas or smoke flues to be topped out with stone, pointed, 4 feet above roof and capped with flag stone. Any additional depth of foundation necessary for perfect solidity, to be extra, and to be done by Contractor at the rate of $4.50 per perch.

Flues.

Brickwork.

All walls tinted red on plans, to be built of hard burnt brick laid in common bond—five stretcher courses to one header course, bedded in plenty of strong sharp sand and lime mortar. One-fourth salmon brick may be used. The brickwork of flues to be all struck joints and not pargetted. Relieving arches to be turned over all lintels where practicable.

Cellar Floor.

Floor of that part of Cellar arranged for heating apparatus and fuel, to be paved with approved asphalt pavement not less than 3 in. thick, the filling having first been made solid by puddling or ramming, as the Architect may direct. Arches between beams of floor and ceiling of Assembly and Library, floor over furnace room and boiler room, to be 4 in. brick with haunches filled in level with top, with a concrete or mortar, brick-bats, coarse gravel, &c. Arches to be constructed over openings under Corridor Walls—wooden blocks, furnished by carpenter, must be walled in wherever required, to which to secure the wood finishings of the interior.

Filling Arches.

Bricklayer must furnish, set up and take away his own scaffold and centres.

Brickwork of heating apparatus, air chambers, fire brick in flues, &c., to be built as directed.

The contractor for brickwork must assist in securing iron stairways in their place, and in the placing of all beams and iron work connected with the brick work.

Large Flues.

The large flues marked X, to start at foundation, and especial care to be taken to keep them plumb and of the same size their whole height. Openings must be left in these flues in each story, 2 feet wide and 3 feet high. The wainscoting at these points to be put in with screws, so that access can be had to the flues.

Asphalt Pavement.

Chimney Tops.

The entire floor of Basement, except the portion used for Water Closets, where no other kind of floor is specified, to be covered with approved Asphalt Pavement, 2 in. thick, the filling having first been made solid by puddling or ramming, as directed. Chimney tops of stone or terra cotta, as per elevations and detail drawings, to be furnished and set. Large ones to be 2 in. thick at the thinnest parts, to be properly made with socket joints and set with cement.

Ventilating flues to be topped out 10 in. above roof and tinned over.

Asphalt Pavement.

The outside pavement, over Boiler Vault, to be of the approved Asphalt before mentioned, 3 in. thick.

Carpenter Work, Lumber, &c.

The contractor for Carpenters' and Joiners' work must furnish all the lumber and other materials required, to do and perform and carefully complete all the Carpenters' and Joiners' work upon the building, agreeably to the drawings, and execute said work in the best and most workmanlike manner, and to the satisfaction of the Architect.

Quality of the Wood.

All the Lumber used must be of the best quality, free from unsound knots, shakes or rot;—it must be well and thoroughly seasoned before using, (by kiln drying when necessary,) and be in a state proper for the various purposes for which it is destined to be used.

Floor Boards.

The boards for the floor over brick arches to be laid on scantling 3 in. by 4 in. fastened securely to the brick work of the arches, by bedding in concrete. All wooden girders supporting floor joist to be composed of three pieces, 3 in. by 12 in. white pine, pinned and strapped together.

Joist.

All joists to be 3 in. by 12 in. all under 20 feet span to be of spruce, and all longer than 20 feet to be of white pine; to be placed 16 in. between centres. All trimmers around flues, (no wood in any case to be within 9 in. of a flue,) stairs, &c., to be double joist pinned together, and where long spans, every third joist to be hung with stirrups. All joists of 16 feet lengths or less to have one row of cross bridging through each tier—all over 16 feet to have 2 rows. All joists to be brought to even widths. All to be backed.

Trimmers.

Cleats.

First, second, and third floors to be deafened by nailing cleats on joist, boarding, and filling in with mortar 1½ in. deep, ½ in. from top of joist.

All floors to be laid with all heart yellow pine, mill-work boards 1¼ in. thick, none more than 5 in. wide, and on first floor none more than 4 in. wide; to be tongued and grooved, and securely nailed to joist and afterwards smoothed off.

Stud Partitions.

Stud partitions to be 3 in. by 6 in. and 3 in. by 4 in. helmlock bridged.

Floor over Chapel.

Floor over chapel to be constructed on six principal rafters, spanning the whole width.

Wall beams to be 4 in. by 11 in. ties or straining beams, to be in three pieces 4 in. by 12 in. blocked apart and bolted together—crossties or curved braces to be two pieces 3 in. by 12 in., these to rest on large stone in wall; braces 4 in by 12 in. Queen posts 12 in. by 12 in. to be properly framed, and have the necessary bolts and straps to make a secure job, and to conform to the detail drawings hereafter to be furnished. These support the floor of the fourth story, which will have 3 in. by 12 in. joist, 16 in. centres—to have three rows of cross bridging, partitions above to be framed to relieve the weight from centre of girders.

Wall plate around the entire Building 3 in. by 12 in. securely bolted to the walls, about 10 feet apart all around. Bolts 3 feet long ¾ in. thick. Wall Plate.

All other roofs of Main Building and wings to be constructed in the usual manner of Mansard Roofs, with side studding 3 in. by 6 in. spiked to plate. Upright studding 3 in. by 4 in.—Upper or roof plate 3 in. by 8 in.—Rafters for short spans 3 in. by 8 in. and 3 in. by 10 in.—For long spans 3 in. by 12 in. as may be directed. Ceiling joist 2 in. by 4 in.

Ties and braces, and all wood work of principal Rafters of Chapel which show below plastering, to be planed smooth and chamfered, and to be varnished and oiled. All the roofs to be covered with tongued and grooved white pine boards, 1 in. thick, firmly nailed to rafters and studding. Ties and Braces.

All outside walls to have stripping 1 in. by 2 in. securely nailed to plugs or strips for lathing. Stripping.

Washboads first story in Corridor and where there is no wainscoting, to be 10 in., including 2½ in. sub. and 1⅓ in. moulding. Washboards.

Second story in Corridor, 8 in. including moulding and sub. Washboards in third and fourth stories 6 in. bevel or bead top.

Washboard throughout Basement, where it is floored with boards to be 6 inches. May be cement where asphalt pavement is laid.

Wainscoting.

In all the large rooms of Main Building and Wings, Assembly in basement, and the window sides of Library, to be wainscoted perpendicularly, 3 ft. 6 in. high, with yellow or white pine clean stuff, 4 in. wide and under, tongued and grooved and beaded to the level of the window sills. Wainscoting.

The window sills forming the cap of wainscoting to have 1½ inch nosed edge with 1½ inch ogee moulding beneath. Washboard in this case to be 6 inch scotia or bevel edge. Capping.

Wainscoting to be left out of those windows required for coils or radiators.

Wainscoting to be put up with screws at opening in clock weight flues.

Windows.

The windows throughout to be double hung, except those Gable and Dormer, which have stationary sash—to conform to the elevations and detail drawings. Windows.

All reveal frames, white pine, with 2 in. bead, or large ogee moulding as may be determined. Reveal Frames.

Sills 3 in. heart yellow pine. Jambs plastered and splayed where marked with 2 in. bead on angle for protection to plaster and finish. Sills. Sash.

Inside shutters.—All basement windows to have inside panel shutters, 1¼ in. thick, cut in middle and made in folds to suit jambs— Inside Shutters.

hung with butts, secured with yellow pine or iron bar and wrought iron staples.

All first and second story windows, except Corridor Windows and on stairs, to have inside pivot or rolling blinds, 1 1/8 in. thick, cut in middle and made in folds to suit jambs.—Jamb shutters to be panelled. Shutters in rooms on either side of main entrance to be made to fold in boxes.

Architraves. Architraves of these to be made to suit the arrangements of the openings. All windows, except Dormer and Gable windows, to be finished square inside. Dormer windows to have 1 1/2 in. sash to small windows, 1 3/4 to large—to be double hung where practicable; all to be made according to the elevations and detail drawing and direction of the Architect.

Dormer Windows.

Side Lights. Side lights of Corridor Doors at ends and interior throughout to be double hung as window sash—Centre lights of Transom Sash to be stationary. Lintels over inside of window openings to be three pieces, 3 in. by 8 in. No shutters to chapel windows.

Door Frames.

Door Frames. Basement door frames in Interior to be made of 3 in. by 4 in. scantling, walled in flush with both faces of wall. Lintels to be 3 in. by 6 in. cut with 4 in. rise, to have 9 in. arch over. Lintels of all doors in brick walls of upper stories, to be made in the same manner.

Doors.

All interior doors in Basement, and all communicating doors in upper stories, except Corridor Doors, and all doors in third and fourth stories, to be six panel 1 3/4 in. thick, and double face doors.—Flat raised panel and chamfered stiles and rails, (no moulding,) all to be 8 feet six inches high. All doors opening on Corridors in first and second stories of West Wing, and second story of East Wing, to be 8 feet 6 inches high, made in the following manner.

Interior Doors. Two doors to be separately made six panel 1 1/4 inch thick flat raised panels chamfered stiles and rails.—One face of each door to be finished. These will be screwed to a frame one inch thick forming a double door with hollow space between, as per detail—all to be hung to open outward into Corridor.—All doors opening on Corridor, and all communicating doors in East Wing first story, to be glazed doors made folding, hung with pivots, to open both ways, and have springs to keep them closed.

Architrave of doors to be 3 1/2 inch moulding and 1 1/2 inch band or their equivalent—no plinths—jambs cased and rebated. Outside doors of basement to be 2 1/4 inches thick, panelled, moulded or chamfered, as may be required on outside face, bead and butt on the back.

Front entrance doors of first story, panelled, moulded and chamfered, as per elevation and details, 2 1/2 inches thick, bead and butt on back. Vestibule doors and interior side light doors 1 3/4 inches thick double face, top panel glass, and side lights of interior corridor doors to be double hung,

transom centre sash stationary. Wood for doors to be cut and put together immediately after contract is signed, and to be thoroughly dry and seasoned before going in the building.

Flooring also to be purchased as soon as possible after signing of contract, that it may be stacked for seasoning before being used in the building.

Front and vestibule doors, first story to be of walnut, also basement east and west and rear entrance doors; all others to be of white pine, clean stuff.

A rostrum to be constructed in chapel, as per plan—the desk to have chamfered stiles and rails, raised panels, moulded cap and base, as per detail drawings to be furnished.

Stairs, &c.

Private stairs. Private stairs at rear of Trustees' room, first to second story to be 1¼ inches thick yellow pine treads—1 inch white pine risers, tongued, glued and blocked. Rail 4½ inches walnut—balusters 2¾ inches maple—newells 8 inches walnut—stairs to cellar in the usual manner. Two flights of plain stairs from basement to first story, at east and west parts of building. Basement stairs. Yellow pine 1¼ inch treads, 1 inch white pine risers, yellow pine 3 inch rail and standards. One flight from third to fourth floors, steps yellow pine 1½ inch, risers 1 inch white pine. Skirting to correspond with washboard of third story.

Lecture room stairs to be same style as private stairs.

To be 4½ inch walnut moulded rail, to main iron stairs.

Skylights. Two skylights to be constructed as per plan and details.

Water closets. Water closets to be fitted up in the basement, with hinged seats. Partitions 1¼ inch capped, 7 feet high, doors 1¼ inch, panelled 5 feet, 6 inches high.

Water closets in first and second stories and basement, where marked on plan, to be neatly fitted up with seats and risers, and hinged lids. Washstands neat panelled doors, sub, &c. Reservoirs to be 2 inches thick plank firmly put together, and properly fitted to receive lead lining. All finished with walnut.

Umbrella stands in first story, hall and in basement where marked on the plans, to be fitted up as directed, to be lined with zinc.

Roofs. Roofs, cornices, and dormer windows to be constructed and finished, as per elevations and details to be furnished.

Ornamental corners of roof cornice, may be of galvanized iron, instead of wood.

Centres for arches, blocks, plugs, scantling, &c., which are to be built in walls, to be furnished at the proper times and places, and all necessary fitting and handling to be done by the carpenter.

Ironwork.

Wrought and cast iron, blacksmithing, &c.

Beams. One girder composed of three beams 7 inches high, (55 lbs. per yard,) to support gable over western rear bay window. Eight girders each composed of two beams 10½ inches high, (105 lbs. per yard,) these support stairs and floor corridor at head of stairways.

Twenty-four girders, each composed of two beams 12 inches high, (125 lbs. per yard.) Each girder to have curved brace from wall, made of two angle irons 5 by 3 inches by 3/8 inch; foot to rest on large stone, and head securely bolted to bottom flanges of beams, spandril to be decorated with cast-iron ornament. These girders are to support the floors in large east and west rooms, first, second, and third stories, two girders in each room, and the beams are to be securely bolted together with a piece of white pine timber, 3 by 12 in. blocked between them—and cast iron separators.

Six girders each composed of two beams 10½ inches high, (105 lbs. per yard,) for assembly floor and library floor and ceiling, running east and west of three spans supported on cast-iron columns.

All girders composed of two or more beams to be bolted together with cast-iron separators, and ends strapped together and anchored into walls, and resting on iron plates.

Beams for first floor over furnace room, to be 10½ inches high, 105 lbs. to be placed not more than 3 feet 9 inches from centre to centre. Beams of assembly floor and library floor and ceiling to be 9 inches high, 70 lbs. to be placed not more than 3 feet 9 inches from centre to centre. All beams to be properly strapped together and anchored in walls where required.

Stirrups. Stirrups to be provided for hanging joist trimmers, &c., where required.

One set of spiral stairs, from basement to first floor, treads 3/8 inch ribbed, risers ¼ inch close, supported on centre staff and ends built in walls.

Principal stairs. Two sets of stairs of three flights each from basement to third floor as per plan. Treads 3/8 inch to be covered with slate treads, risers 3/8 inch close lattice, panelled or ornament, as per detail, all to be supported on three strong wrought-iron bars and cast-iron carriages—ends built in wall.

Newells. Balusters. Newells at starting in basement 10 inches, and in first story 14 inches, of Gothic pattern. Balusters, ornamental castings to be selected. The upper step of each flight and its nosings, to continue around the landings to receive railing, which must be secured to them as to the steps. Facings of the well hole must be of iron extending down to receive the plaster of ceiling below. Arranged for walnut hand-rail, to be three feet high when all is finished.

Gratings of iron bars to be leaded in flag-stone cappings of all area walls—to have folding gates at all windows.

Columns. Cast iron columns where marked on the plans.

Four columns 9 in. diameter, ¾ in. thickness of metal in cellar, to have four base plates 2 ft. by 2 ft. by 1¼ inch thick.

Four columns 9 in. diameter in basement ¾ in. thickness of metal.
Four columns 8 in. diameter ¾ in. thickness of metal in first story.
Four columns 7 in. diameter ½ in. thickness of metal in second story.
Four columns 6 in. diameter ½ in. thickness of metal in third story.

These rest on each other, and must be made with saddle heads and the girders to go through them.

Two columns 10 in. diameter ¼ in. thickness of metal for front hall under chapel, to have base plates 1 ft. 3 in. by 1 ft. 3 in. and 1 in. thick.

Four box posts 6 in. by 1 ft. 6 in. and ½ in. thickness of metal, to have bracketed skew back heads for brick arches of corridor walls, base plates to be 1 ft. 6 in. by 1 ft. 6 in. and 1 in. thick.

All columns to have moulded caps, as per detail to be furnished, to be in proper proportion with their respective lengths.

All bolts, jambscrews, stirrups, clamps, anchors, &c., necessary for a complete and substantial job, to be furnished, if not specially mentioned.

Cast-iron cresting, pattern selected for bay windows. Crestings. Cast-iron railing or cresting, to be set on roof as per elevation and detail drawings.

Three set of inside and outside doors for fire proof. In- Fire proof doors. side doors folding—outside single doors—with wrought-iron frames to be set complete. Usual fire proof locks and fastenings, ($25 lock.) The contractor for ironwork must build and set up and take down his scaffold; carpenter must furnish all the material for making it.

Two base plates 12 in. by 12 in. by 1 in. and two plates Plates. 1 ft. 6 in. by 3 ft. by 1 in. Six columns 4 in. diameter. Two 8 in. beams, (65 lbs. per yard,) and six beams 6 in., (40 lbs. per yard.) Two of these to be bolted together with separators. These are to support the arches of boiler room and rear wall. One Hyatt Vault Light 3 ft. diameter over boiler room to be furnished and set.

Hardware.

All doors that are made double as described, to be hung Butts, &c. with 7 in. Baldwin's Patent, or American butts equally as good. Heavy mortise brass works latch 3½ in. by 4½ in. box, with brass knob.

All doors of eastern wing first story, which are made folding, to be hung with pivots and have suitable springs and fastenings.

Dead-latches to be furnished to all the doors required at Dead-latches. $—— per lock, to be hereafter selected—not included in contract. Outside front doors, main entrance, to have top and bottom flush bolts, heavy wrought polished face; top bolt long enough to be easily reached. Bottom bolt 12 in.; lock mortise rebate—Russell & Erwin's make, 8 in. box and bronze knobs.

Doors to be hung with three pairs 6 in. by 6 in. fancy imitation bronze butts.

All basement and interior doors of upper stories to have brass or bronze knobs; iron butts sufficiently large to swing door clear of architraves or finishings; and to have suitable brass works locks. Vestibule door entrance to have butts 6 in., top and bottom bolts to be all the same as front door, except vestibule latch instead of lock. All windows to Cotton cord.

be double hung with best cotton sash cord, suitable thickness for the different size of windows. The best pulleys with brass journals to be used. Weights to be of cast-iron. All windows to have two iron sash lifts each, and a sunk eye in top rail of top sash.

Strong sash fasteners of approved construction to basement and first story windows throughout. Sash fasteners.

Plumbing.

Four-inch cast-iron proved pipes, with leaded joints, for draining water from roof, to run up to tops of French Roofs inside of Rafters, and be provided with Y branches, to connect with main Cornice Gutters; below these, pipes to be built in wall, all to connect with 6 in. Terra Cotta Drain Pipe below floor of Basement, to connect with main centre 10 in. to centre of Building, and thence 12 in. Terra Cotta Drain Pipe to run 10 ft. outside of Building. Two additional 4 in. iron pipes to be used for Water Closets in Basement, First and Second Stories; one 3 in. pipe for draining water from porch, and one 3 in. pipe from each of the Bay Windows. Roof Conductors. Drain Pipe.

A 3 in. Cast Iron Water Pipe from 10 feet outside of Building at West End; to branch off 3 in. cast-iron pipe to 3 ft. above Third Floor, at each end at line of Water Closets with outlet at each story, and 2 in. pipe to extend to rear of Boiler Room in Cellar, to have fire hose attachments, two in each story and one in Cellar, with large brass cock screw nozzle, suitable for 2 in. hose. Water Pipe.

Two Water Closets in Basement, three in First story, and two in Second story where marked on plans, to be the best Valve Closets, to be hereafter selected by the Committee or their Architect. Water Closets.

All to have hinged seats, to use as urinals, to be lined with soft Medallion Metal or 5 lb. lead, to be determined—dressed closely against the under seat, and to extend ½ in. under the hole—supplied with ⅝ in. lead connection with each Water Closet. Tank.

Each Water Closet in the Second story to be supplied with 5 lb. lead-lined reservoir or boiler-iron tank, each tank to contain 50 gallons. Tanks.

A wash basin in each Dressing Room, 14 in. China basin—Craigie's combined basin trap and plug to be used, countersunk marble top 20 in. by 30 inch., and back and moulded edge. Silver plated cock and plugs; supply, ½ inch lead pipe for cold water, 1¼ inch lead waste pipe from basins to run into soil pipe of Water Closets. Twelve Water Closets in Front Basement to be self-acting, (Carr's patent,) Hopper Valve Closets and seats combined, to be secured to Flag Stone, each to be trapped separately and drawn into 8 in. drain pipe connecting with main drain; supply pipe 1 in. lead. One Enamelled Basin Stand and Frame, Cold Water supply ½ in., waste 1¼ in. lead pipe, brass cock, in each water closet room in basement, four in all. Umbrella Stands to be lined with zinc and to have 1½ in.

waste. A 3 in. stopcock to be put on Main outside of Building, and a 2 in. stopcock to each supply main that runs up to third story, and a ⅝ in. stop and waste on all other supply pipes.—½ in. supplies to be 2½ lbs. per foot, ⅝ to be 3 lbs., and 1 in. to be 4⅔ lbs. per foot, waste 1¼ in. to be 2½ lbs., and 1½ in. to be 3½ lbs. per foot.

Provision to be made for the introduction of additional supply and waste pipes, sinks, cocks, &c., which will be hereafter specified and separate contract made for the same.

Gas.

Gas Pipes for lighting the Building to be introduccd according to regulations of City Gas Works, allowance to be made for about 450 burners. All outlets to be in Ceiling, except in Chapel, which are to have side outlets. Rooms measuring about 30 by 45 feet and 50 ft. to have four outlets—those measuring about 24 ft. by 34 ft. to have two outlets, smaller rooms one outlet. Corridors to have five outlets each, all other rooms and passages as may be directed. Arranged for one or more burners as may be desired. No fixtures to be included.

Additional Pipes and Outlets to be provided for such rooms as may be directed, and allowance made for   burners, a detailed statement to be hereafter furnished.

Plastering.

All Walls to be finished from the float, rough-cast finish. Entrance Hall, Assembly, Stairs and Corridors, of the first and second stories, to be lined off in blocks; all to be tinted in mortar of light drab color. All Ceilings to be strictly three-coat work, first coat to be dry before being followed up, (two coats of Brown, and one of White Hard Finish.) Plasterer must furnish, put up and take down his own scaffold. Skirting on stairs to be of Cement. Front Vestibule and Entrance Hall to have a neat cornice. All Corners to be chamfered not otherwise specified or directed.

Painting and Glazing.

All outside woodwork or ironwork to be painted three coats pure white lead and linseed oil in such tints as may be directed. Outside doors of Basement and First Story to be varnished and oiled. All Interior Woodwork usual to paint, to be varnished three coats. Stiles of doors to be stained slightly darker than panels, mouldings of wainscoting, &c., also to be stained darker if required. Inside Shutters same style. Rafters in Chapel to be varnished, Ironwork to be painted three coats. All Glass to be first quality American Double Thick for large, and single thick for small lights, to be well bedded, bradded and back puttied. Windows of Water Closet Rooms in Basement to have ground glass. Chapel and Stairway windows to have double thick American glass. One Communicating Door East Wing First Story, where directed, to have one large light, French Polished Plate Glass. Skylights to have rough plate glass ½ in. thick.

Heating.

The Contractor for Heating and ventilating the Building must furnish all the materials and work required of the best quality. The heating to be done by a low pressure steam apparatus, consisting of Boilers. Three Boilers, located in the apartment provided, any two of which Boilers will be of capacity and form equal to heating the entire Building in the coldest weather.

To be connected with as many coils, located in the cellar and Basement, as are required for the purpose; which must be connected with boilers by proper flow and return pipes. These coils must be placed in proper chambers constructed with brick walls, into the bottom of which must be admitted from cold air shafts from the top of the Build- Hot Air Chambers. ing, the necessary quantity of pure fresh air to supply at all times the full amount required for heating and ventilating the Building. In these cold air flues, proper valves or registers to control and regulate the amount of air to be admitted into the above chambers to be provided. Connections with distant flues from cold air shafts, to be made with 20 and 24 in. Terra Cotta Drain Pipe as per plan, and as may be directed.

A suitable arrangement of coils in the rooms to be heated, to be used as an auxiliary to the fore-mentioned heated-air arrangement. All large Rooms in 1st, 2d, and 3d Stories to have one or more such Radiators.

The coils must have around them suitable ornamented screens, supporting a marble slab 1¼ inch thick. Their flow and return pipes must be so carried as to be concealed from view.—All Coils must be on the window side and where directed. The Contractor must guarantee that the rooms can be kept at a temperature of 70°, and the corridor 60°, when the thermometer stands at 20° outside.—The Entire Basement Temperature. and the Halls and Corridors of the upper stories, to be heated by direct radiation.-- All the rooms above the Basement to be heated half by direct radiation, and half by the heated Air from the hot-air chambers above mentioned; pipes and coils to be so constructed as to prevent any snapping and cracking noise. One low grate to be set in private Grate. room, adjoining dressing room in West Wing where marked on the plans, to be No. 1½ Black Grate; and one Marble Mantel fur- Mantel. nished and set by Contractor, to cost not less than $60.

Slate hearth to be set, Ash-pit door also to be furnished and set. All Registers to be black japanned, to be furnished and set com- Registers. plete, to all hot air and ventilating flues, and of suitable style and size for the capacity of flues.

Tinning, Slating, &c.

The upper flat roof, as per plan, and all the Gutters, Cornices, and Battlement Walls and Ventilating flues, to be covered with best Tin. 1 cross M. F. charcoal tin, painted on both sides, the upper to have two coats. The Gutter tin to have three coats. All chimneys, battlements,

and hips must be flushed, puttied and made perfectly water tight. The water to be taken off through 4 in. cast iron pipes, as before described in plumbing. Suitable Galvanized iron or copper Basket Strainers. strainers to be set in all outlets. Porch and Bay windows to be covered with tin.

All the steep roofs to be laid with best Susquehanna Slate on felt. Roofs of corner dormers, centre building, to be red slate—red Slate. and green slate border in roof cornice of main building, as per elevation.

Bells—Speaking Tubes.

Bell tubes to be inserted in Wall before plastering—number and position as directed. Speaking tubes also to be put in where required and have the proper mouthpieces.

Lightning Rods.

Of Iron with screw joints to be secured to the Building at sufficient number of points to thoroughly protect it, to be of suitable size and kind to be approved by the committee. Each rod to be provided with four points.

Contractor to pay for all permits and make the attach- Permits. ment for water supply from the street main.

Towers.

The extension of towers of east and west ends, above the gables, to be constructed of Serpentine stone, as per elevations, with Ohio stone dressings and cornice, according to detail drawings to be furnished.

Roofs to be hipped, covered with Susquehanna slate with red border at the top—the whole to be surmounted by railings and finials of iron.

Window frames to be double hung with stationary transoms as per design. Floors to be laid about 3 ft. below each window, and rough stairways or stepladders for ascent to the same to be constructed.

Should it be decided not to build the upper section of towers—the four gables are to be capped with stone, finished with iron finials and the intersecting roofs to be covered with slate—the pinnacles or chimneys on the four corners of each to be of stone and terra cotta as directed.

Railroad Specifications.

For a Passenger Depot.

See page 273.

Specifications

For a Passenger Depot for the Baltimore and Potomac Railroad Company, to be Erected at the Corner of B Street north, and Sixth Street east, in the City of Washington.

These specifications are intended to embrace the entire superstructure above the foundations, with everything pertaining to it complete, and finished up ready for occupancy. The whole of the said building to be comprised within any contract or contracts which may be made for the same, excepting only the foundations before referred to, and certain items which will hereinafter be particularly specified.

The entire work is to be constructed and finished in every part in a good substantial and workmanlike manner, according to the accompanying drawings, and these specifications, to the full extent and meaning of the same, and to the entire satisfaction, approval and acceptance of the engineer and architect, and under the supervision and direction of such agent or agents as he may appoint.

The following is a list of the drawings which accompany these specifications, and which form part thereof:—

No. 1. Elevation on B street.
No. 2. Elevation on Sixth street.
No. 3. South elevation.
No. 4. West elevation.
No. 5. Plan of first story.
No. 6. Plan of second story.
No. 7. Plan of third story.
No. 8. Plan of roof.
No. 9. Plan of iron beams of first floor.
No. 10. Plan showing gas, steam and water pipes.
No. 11. Longitudinal section.
No. 12. Traverse section.
No. 13. Details of cornice, &c., of main tower.
No. 14. Details of tower over entrance on B street.
No. 15. Details of main cornice.
No. 16. Details of granite base.
No. 17. " " " "

No. 18. Details of dressed stone work.
No. 19. " " " " "
No. 20. Details of stone work of balcony on B street.
No. 21. Details of galvanized iron work.
No. 22. " " " " " of spire.
No. 23. Details of dormer windows.
No. 24. Details of trusses, girders, &c.
No. 25. Sundry details.
No. 26. Details of main skylight.

Additional drawings.

Additional detail and working drawings will be furnished in exemplification of the foregoing, from time to time, as they may be required; and, it is to be distinctly understood, that all such additional drawings shall be of equal force with those which are herein specifically cited; and the said additional drawings are to be considered as virtually embraced within, and forming part of these specifications.

Alterations, additions and omissions.

It is also understood that the engineer and architect of the building shall have the right to make any alterations, additions, or omissions of work or materials herein specified, or shown on the drawings, during the progress of the building, that he may find to be necessary, and the same shall be acceded to by the contractor or contractors, and carried into effect without in any way violating or vitiating the contract, and the value of all such alterations, additions, or omissions shall be agreed upon in writing between the said engineer and architect and the contractor, before going into execution, or no allowance will be made for them by either party.

Care of finished work.

Particular care must be taken by the contractor of all the finished work, as the building progresses, such as exterior projections, cut stone, stairs, washstands, &c., which work must be covered up, and thoroughly protected from injury or defacement during the erection and completion of the building.

Removal of rubbish, &c.

All the refuse material and rubbish that may accumulate during the progress of the work, to be removed from time to time, as may be directed by the engineer in charge, and on the completion of the work, all the streets and ground must be thoroughly cleaned up, and the surplus material and rubbish carted away.

The contractor is to assume all risks, and bear any loss occasioned by neglect or accident during the progress of the work, until the same shall have been completed and accepted by the engineer and architect. He is also to assume all blame or loss by reason of neglect of city or district ordinances, encroachments upon neighbors, or from any other cause. And it is to be distinctly understood that the engineer in charge of the work shall have full power, at any time during the progress of the same, to reject any materials he may deem unsuitable for the purpose for which they are intended, or which are not in strict conformity with the spirit of these specifications. He shall also have the power to cause any inferior or unsafe work to be taken down and altered at the cost of the contractor.

These specifications are to be understood as not including the foundations, and the stone masonry below the first floor, all of which will be finished off to receive the dressed stone on the two street fronts, and to receive the floor beams on the other walls. Foundations not included.

Dressed Stone Work.

The fronts on B and Sixth streets to have a base of first quality granite, either from the Richmond or the Old Dominion quarries, of the heights, lengths and sectional forms shown on the detail drawings. The beds of the lower course to be from 20 to 24 inches; of the second course from 12 to 15 inches, and of the third course from 15 to 18 inches. Granite base.

The steps of the entrance door, and the check blocks of the same, also all the outside door sills, and steps to be made of the same kind of granite as the base of the building. Steps. Door sills.

The rest of the dressed stone work, consisting of caps and bases of columns, sills, lintels, string courses, corbels, brackets, window dressings, and other features designated on the drawings, to be composed of Ohio sand stone, of good uniform color, without flaws, spots or streaks. Sand stone.

All the dressed stone work to be well and finely wrought, and the beds and ends brought to perfectly plane surfaces, so as to make close joints; all mouldings, projections, ornamental caps and bases of columns to be finely and accurately cut, according to the drawings. Beds and ends. Mouldings, &c.

Iron cramps and dowels to be used wherever necessary for the stability of the work. Iron cramps.

The shafts of the columns at the doors of entrance on Sixth and on B street, and the shaft of the column under the balcony on B street to be made of Aberdeen granite, finely dressed and well polished. Polished columns.

The base, string course and cap of each of the chimney tops to be composed of Ohio sand stone, well cramped with galvanized iron. Chimney tops.

Brick Work.

All the outside walls above the base course, and all interior walls designated on the plans, are to be built of good, sound, well-burnt bricks, laid true and straight, and properly bound together with heading courses. In the main fronts the headers are to be introduced behind the running bond, so as to tie the outside four inches to the rest of the wall, without appearing on the face. The mortar to be composed of the best quality lime, and clean sharp-gritted sand, properly mixed, and thoroughly manipulated. Bricks. Mortar.

The outside walls to be faced with the best pressed bricks of uniform color, laid in colored mortar, with joints not exceeding one-eighth of an inch (⅛″) in thickness. Front Bricks.

Courses of encaustic tiles are to be inserted in the face of the walls on the two street fronts, wherever they are indicated on the plans. Encaustic tiles will also be used for flooring the general waiting-room, the Encaustic Tiles.

hall, the restaurant, and the water-closet rooms. The patterns, as well as the make of the tiles, to be decided on in all cases by the engineer and architect.

Relieving arches to be turned over all openings that will admit of them. Relieving Arches.

All the flues are to be well built and carefully pargetted.

The first floor to be formed of brick arches, one brick (4″) thick, turned from wrought iron floor beams, and the haunches filled up with concrete, to the proper height for the tile, or the wooden flooring, as the case may be. The mortar to be used in these arches, and in the concrete filling of the haunches, to be composed of hydraulic cement, and clean sharp-gritted sand. Floor arches. Concrete filling. Cement.

Iron Work.

The first floor throughout the building, except in the boiler room, to be constructed on wrought iron floor beams, the various sizes, lengths and spacing of which are given on drawing No. 9. The bearings are to be slate, each of which must be eight by twelve inches (8″×12″) and two inches (2″) thick. Floor beams. Slate bearings.

The Main Tower.—The following portions of the main tower will be composed of galvanized iron, to wit:—The dormer windows on the four sides of the tower, including the cornices and the returns to meet the roof; also the angle corners and cornices of the roof of the tower. Cast iron will be used in this tower in the cornices of the second story, the balconies and the frieze, the columns, capitals, and bases of the windows of the third story, with the imposts, arches, cornices, and columns above them; also in the plain faces back of the columns. The clock faces on the four sides of the tower, including the panel work on each side of the same, will likewise be composed of cast-iron; the clock dials to be made separate, so as to admit of being removed. Galvanized iron. Cast iron. Clock faces.

The railing of the balconies will be composed of wrought iron. Railings.

Tower over Entrance on B Street.—In this portion of the work *galvanized iron* will be used in the cornice and finial of the gable; and *cast iron* in the columns, capitals, bases, pilasters, sill and hood of the third story window, with the two adjacent corner columns, including their capitals and bases; also in the dressings of the circular window. Galvanized iron. Cast iron.

Tower over Baggage Entrance.—The main cornices, modillions, and angle corners of the roof to be made of *galvanized iron*. The entrance to the baggage room to be spanned by a boiler plate girder, supported by *cast iron* brackets. Galvanized iron. Boiler iron. Cast iron.

Octagonal Tower on B Street.—The main cornices, modillions, and angle corners of the roof to be made of *galvanized iron*. Galvanized iron.

Main Cornices.—All the main cornices of the building, including the modillions and the frieze cornices, to be made of *galvanized iron*; also all the gutters, valleys, and flashings. **Galvanized iron.**

Dormers.—The three dormer windows on the east front, the three on the north front, and the four on the west front, including all their parts, except the crests, to be made of *galvanized iron.* **Galvanized iron.**

The rear or south wall, to be capped with a galvanized iron coping. The corner columns of the said rear wall, as shown on drawings Nos. 2 and 3, to be made of *cast-iron.*

The galvanized iron work to be supported by rough wooden brackets, to which the iron must be securely fastened. The whole to be well wrought, in conformity to the drawings, and put together in the most substantial manner, and in such a way as to prevent the admission of water in any of the joints, or in any of the connections with the other features of the work. **Rough bracketing.**

The cresting and the finials of the towers, to be composed of *wrought iron,* and all the rest of the cresting throughout the building to be made of *cast iron.* **Cresting.**

The iron work attached to the roof to be secured by wrought iron chairs and stays, galvanized wherever they rest on the tin roofing. The screw heads to be covered with tin caps, soldered to the roof, to prevent leakage. **Wrought iron chairs and stays.**

The two columns in the restaurant, the two over them in the second story, and the two in the third story to be composed of *cast iron.* Iron girders, each consisting of two 12-inch I beams of 150 lbs. to the yard, to be placed on these columns. **Iron columns.** **Iron girders.**

All cramps, ties, tension bars, truss rods, bolts, stirrups, bars and other iron work required in the various parts of the building, to be furnished of the first quality wrought iron, and made in the best manner, snbject to the directions and approval of the engineer in charge; it being understood by the parties to the contract that such bolts, bars, cramps, stirrups, &c., are to be introduced at the discretion of the said engineer in charge, wherever he may deem it to be necessary to assure the strength and permanency of the building. **Miscellaneous.**

All the castings required in the execution of the work, whether herein particularly specified or not, to be made from good tough iron, true and sound, and free from cracks, flaws, bubbles, or defects of any kind whatever.

All the galvanized iron used in the building, to be of the best quality, designated as No. 28.

Lumber and Carpenters' Work.

All the lumber throughout the building, except where particularly specified to the contrary, to be first quality white pine, free from shakes and flaws and unsound knots, thoroughly seasoned, and in every way suitable for the various purposes for which it is intended. **Lumber.**

All joists of 20 feet or more span, are to be four by twelve (4″×12″) white pine, and wherever the span is less than 20 feet, three by twelve (3″×12″) joists are to be used. The ceiling joists of the attic story may be three by eight (3″×8″) hemlock. Joists.

The rule for spacing the joists throughout the building shall be sixteen inches (16″) from centre to centre.

Each joist must be properly backed, and have a bearing of four inches (4″) at each end, on the walls and partitions. In all cases where joists are supported by girders, they must lap each other, so that each joist shall have a bearing equal to the whole width of the girder.

All floors of joists of more than sixteen feet (16′) span, shall be stiffened by two rows of cross bridging, and in cases where the span is sixteen feet, or less, with one row. Bridging.

Flues and other openings are to be framed around with double trimmers, in all cases where there are more than one tail joist. Particular attention must be paid to keeping all woodwork sufficiently far from the flues to insure absolute safety from fire. Trimmers.

The wooden partitions throughout the building are to be made of good white pine scantling, spaced sixteen inches (16″) from centre to centre, securely attached to the floors and ceilings, and stiffened with two rows of horizontal bridging. The partitions of the first and second stories are to be composed of 3″×6″ scantling, and those of the third story of 3″×4″, with the following exceptions, to wit: those occurring in the second story, between C and C, on plan No. 6, will be made of scantling 3″×8″; those in the third story marked K and K, on plan No. 7, and the backs of all water closets in the building will be made of scantling 3″×8″. In all cases throughout the building, the broad side of the timber is to be placed cross-wise of the partitions. Partitions.

The outside walls to be furred with three by six (3″×6″) scantling, secured to horizontal strips built in the walls as the work progresses. Furring.

All the window frames in the building to be made *reveal*, of sound, well seasoned white pine lumber, fitted with all the necessary pulley styles, boxes, pockets, parting strips, beads, &c., in accordance with drawings. Windows.

Dormer windows to be made on the roof, as shown on the drawings; the fronts and the sides will be composed of galvanized iron, to which wooden frames, with all the necessary boxing and interior finish will be attached. The iron work is provided for under the head of that material. Dormers.

All the windows in the building to have inside shutters, one and one-eighth inches (1⅛″) thick, cut at the meeting rail, and made with moveable sloats. Those of the first and second stories on the two street fronts to be composed of walnut, and all the rest of white pine. Shutters.

The finish around the windows to consist of a two and a half inch (2½″) corner bead in the first and second stories, and one and a half inch (1½″) bead in the third story.

All the windows to have plastered jambs, and interior sills of hard wood, one and a half inches (1½″) thick, finished with nosed edges and moulding, returned on the ends. Window sills.

The sash to be composed of first quality white pine, one and three-quarter inches (1¾″) thick, made in accordance with the drawings. The upper sash of the bay window, the sash of the baggage room, and the upper sash of the window above it, also the upper sash of the windows in the second story of the tower, and the sash above the transoms of all the windows of the principal story throughout the building, to be hung on hinges. All the rest of the windows in the building to be double hung on strong axle pulleys, with the best patent cord, and finished as shown on the several drawings. Sash.

The outside doors to be two and a half inches (2½″) thick, made of two thicknesses of one and a quarter inches (1¼″) each, panelled on both sides. Doors.

The inner doors to be one and three-quarter inches (1¾″) thick, excepting the door in the attic, the thickness of which will be one and a quarter inches (1¼′). The water closets to have short slat doors hung twelve inches (12″) above the floor. All the rest of the inner doors to be panelled on both sides.

The three doors leading from the general waiting room to the passenger platforms to be covered on both sides with leather, and hung on the most approved spring hinges, opening both ways (in and out). Fly doors.

The two outside doors of the baggage room to be hung on eight inch (8″) cast iron sheaves with wire rope and weights to move up and down, as shown on drawing No. 25. Doors of baggage room.

All the doors throughout the building to be made of the best white pine, mortised tenoned and glued up and wedged in the best manner, moulded on both sides, hung on the most approved strong butt hinges, and furnished with locks, bolts, &c., complete, as provided under the head of hardware.

The doors throughout the first and second story, except those leading to the water closet rooms, to have segmental heads, and transom lights, with moveable sash hung on swivels and opened by cords and pulleys. Transom lights.

The doors of the attic story will have square heads without transom lights.

The architraves around all the doors of the first and second stories to be not less than five inches (5″), and those of the attic story not less than three and a half inches (3½″) wide. Architraves.

In constructing the wooden partitions, double studs are to be placed each side of all the openings.

A baggage elevator to be constructed in the baggage room, lifting from the first to the second story, and a gallery to be made around the said room, with permanent steps leading from the first floor to the gallery, and from the gallery to the room above; all of which is to be executed in conformity to the plans. Elevator.

Closets to be fitted up throughout the building, with shelving averaging one foot in width, and with strips three and a half inches (3½″) wide, and one inch thick, provided with first quality hat and coat hooks; and all the necessary shelving, drawers, wall strips, &c., to be provided and put up in the pantries. Closets. Shelving.

A panelled counter to be made across the entire width of the restaurant, with a desk on one end, as shown on plan No. 5, and a marble top of twenty-six inches (26″) in width, and one and a half inches (1½″) in thickness, made in four lengths, and moulded on the outer edge. Counter in restaurant. Marble top.

The three waiting rooms on the first floor, and the gallery of the second floor, over the general waiting-room, to be wainscoted with the best white pine, to the height of the sills of the windows, according to the designs and dimensions indicated on drawings Nos. 11 and 12. The baggage-room will be finished with yellow pine wainscoting four feet (4″) high, tongued and grooved. Wainscoting.

All the rooms having wooden floors to have wash-boards tongued into sub-plinths one and a half inches (1½″) thick, and 2½ inches (2½″) high, screwed into the floors. The washboards in the rooms that are tiled are to have no plinths. All the washboards throughout the building to be moulded on top; those of the first story to be ten inches (10″) high, of the second story nine inches (9″), and of the attic eight inches (8″), all of which are to be made as shown on the drawings. Washboards.

The stairways to be constructed on three by twelve (3″ × 12″) white pine horses, with all the necessary framing secured to the floors and partitions. The steps to consist of one and a half inch (1¼″) yellow pine step boards, and one inch (1″) white pine risers, glued and blocked together, nosed and finished with scotia, and fillet returned on the ends. Stairways.

The main stairway to start from an ornamental newel twelve inches (12″) in diameter, as shown on drawing No. 25, and to have a moulded walnut rail four inches (4″) thick by seven inches (7″) wide, supported by two and three-quarter inch (2¾″) octagonal walnut balusters, with turned mouldings and square plinths; *two* balusters to be placed on each straight step, and *one* on each winder. Main stairway. Newel. Handrail. Balusters.

A skylight to be constructed in the roof, over the main stairway, four feet (4′) wide by eight feet (8′) long, covered with English rolled glass three-eighths of an inch (⅜″) thick, permanently laid, so as to effectually exclude the weather. Skylight over stairway.

A sash four feet (4′) wide and eight feet (8′) long, with semicircular ends, to be constructed below the exterior skylight, and glazed with ornamental glass. Sash.

A plain light stairway, with newel and railing to be made from the third story of the tower to the clock-room. Stairway to clock-room.

All the floors of the *first* and *second* stories to be composed of first quality southern heart pine boards one and a quarter inches (1¼″) thick, in widths not exceeding six inches (6″). The whole to be free from sap, unsound knots, and shakes, and to be tongued and grooved, well planed on top, and securely secret nailed to the joists. The floors above the second story may be laid with yellow pine boards of one inch (1″) in thickness, tongued and grooved, and laid in the usual manner. Floors.

There will be no wooden floors in the general waiting room, the hall, the restaurant, and the water-closet rooms, as these apartments are all to be tiled. The wooden floors of the principal story will be laid on scantling, imbedded in the concrete in the haunches of the arches.

All the floors in the building to be planed, and left clean and perfect on the completion of the work.

Permanent seats are to be constructed around the sides of the general waiting room, as shown on the drawings. The bottoms are to be composed of hard wood, supported on turned legs, placed not more than six feet (6′) apart. The seats to be divided by wrought iron arms of the Pennsylvania Railroad Company's pattern, spaced twenty inches (20″) from centre to centre. Seats.

The roof to be supported by nine principal trusses to extend across the building from north to south, and to be spaced as shown on plan No. 8. The two trusses which rest on the tower to be shorter than the rest, and the one coming under the spire to be longer, as will appear from the drawing referred to. Three short trusses will be required to span from the westernmost principal truss to the west wall; the sizes, arrangement, and details of these are shown on drawings Nos. 8 and 24, which must be closely followed in the construction. Roof trusses.

The frame work of the tower and the spires to be constructed as represented on the drawings, and securely anchored to the walls. The tower to have *eight* vertical anchor bolt, each, one and a quarter inches (1¼″) in diameter, to extend from the top of the belting course next below the clock face to the wall plate, secured at the bottom by wrought iron anchor plates, each three feet (3′) long, three inches (3″) wide, and one inch (1″) thick. The spires to be anchored to the walls in the same way, by *four* anchor bolts in each spire, one inch (1″) in diameter, and eight feet (8′) in length, secured by wrought-iron anchor plates, each two feet (2′) long, three inches (3″) wide, and one inch (1′) thick. Anchor bolts. Anchor plates.

The portions of the four principal roof trusses, which are exposed above the general waiting-room, to be dressed and chamfered, as indicated on the drawings.

A girder to be placed across the opening from A to A, Girders. on plan No. 6, to carry the floor joists. This girder is to consist of two thicknesses of timber, each six by twelve inches (6″×12″), placed one inch apart, and securely bolted together with three-quarter (¾″) combination bolts, keyed with white oak, and supported at two points by rods from a trussed girder placed over the same opening in the story above, and which is also designed to carry two of the principal roof trusses.

Girders are to be placed at B B and B' B', on plan No. 5, to carry the floor joists. These girders are to be supported by a rod from each principal roof truss where it crosses them above, and are each to consist of two pieces of white pine, four by twelve inches (4″×12″) bolted together with three-quarter inch (¾″) combination bolts, and keyed with white oak.

The floor of the clock-room in the main tower to be Clock-room floor. strengthened by two transverse trussed girders.

The sheathing of the roof to consist of the best quality Sheathing. white pine sheathing boards, one inch (1″) thick, planed on one side, and well nailed to the rafters or purlins.

The contractor is to provide and fix all rough bracketing, Rough bracketing. and other carpentry necessary to form the projecting eaves, and all other portions of the iron work in which wooden bracketing may be required, the designs for which are shown on the drawings. Also, all the bracketing and furring necessary for the proper execution in stucco, of the cornices and panelled ceilings. He is also to furnish and provide all the Scaffolding, &c. requisite scaffolding, centering, cradling, furring, beads, fillets, blocks to support bracketing, lintels, strips, and all other articles connected with carpentering, which may be necessary for the proper construction and completion of the work.

The following portions of the general waiting-room, and Ornamental wood work. the hall above it, will be executed of wood, to wit: the corbels, brackets, columns, capitals, and bases, the pendants, pedestals, railings, and the cornices under the galleries, all of which will be made of white pine, and finished according to the full intent and meaning of the drawings.

All the carpenters' work throughout the building to be Miscellaneous. executed according to these specifications, and the drawings hereinbefore referred to, and such additional drawings as may hereafter be made in exemplification of the same; and all carpentry not herein mentioned, and which may be necessary for the complete and proper execution of the work to be faithfully done and furnished.

Plastering.

All the rooms, halls, stairways, and all other portions Rooms to be plastered. of the interior of the *first* and *second* stories of the building; also *six* of the rooms in the *third* or attic story, with the stairway in connection with the same, and the clock room in the tower, to be well

plastered in three coats. The ceilings to be floated, set, and finished with a white coat. The walls and sides of all the rooms to be finished with the float, and tinted as may be directed by the engineer in charge. The remaining rooms of the third story are not to be plastered.

Ceilings. Walls. Tinting. Rooms not to be plastered.

All the rooms in the *first* and *second* stories to have stucco cornices, made in conformity to the designs indicated on the drawings.

Stucco cornices.

The materials to be of the best quality, and the work to be executed in a good and workmanlike manner.

Whatever jobbing and repairing may be necessary, to render the building perfect before its final acceptance by the engineer and architect is to be well and truly done without extra charge.

Jobbing.

Plumbing.

Three of the best water-closets to be put up in the ladies' private room, *eight* in the gentlemen's private room, *six* in the water-closet room of the second story, and *one* in the attic. Each closet to have a "Monitor container," a porcelain bowl, a bronze pull, and a four inch trap made of lead, weighing 5 lbs. to the foot, discharging into eight inch (8″) cast-iron mains leading into an underground terra cotta drainage.

Water closets.

Six large size porcelain urinals to be put up in the gentlemen's private room, and *two* in the water-closet room of the second story. Each urinal to have a three-quarter inch (¾″) brass supply, and a five eighths of an inch (⅝″) stop cock with a cap on top, and a one and a half inch (1½″) waste pipe.

Urinals.

All the water closets and urinals to be furnished with the necessary traps and fixtures to insure certain action, and to promote cleanliness.

Traps, &c.

The backs and floors of the urinals to be composed of slate, and to be five feet (5″) high from the floor. The sides are to be made of wood.

A soapstone sink, four feet (4′) long, twenty inches (20″) wide, and six inches (6″) deep, to be placed in the kitchen, with hot and cold water cocks and the necessary drain pipes; also a large sized plate drainer.

Kitchen sink.

Three permanent washstands to be put up in the ladies' private room, *six* in the gentlemen's private room, and *two* in the water-closet room of the second story, all of which are to have one and a half inch (1½″) marble countersunk tops and backs, and fourteen inch (14″) porcelain bowls, with plated cocks, plugs and chains, and the necessary waste pipes.

Washstands.

Each branch of the supply pipes to have a separate stop and waste cock. All the supply pipes to be extra heavy, and all the work to be done in the best and most substantial manner.

Stop cocks.

The water to be carried from the roof by means of cast-

Roof conductors.

iron pipes four inches (4″) in diameter, securely caulked with lead. The said pipes to be either built in the walls as the work progresses, or carried down in recesses left in the brick work for the purpose, as may hereafter be directed. Each conductor to have a cast-iron elbow at the foot, from which the water is to be conveyed to the sewer by means of terra cotta drain pipes of twelve inches (12″) in diameter. The location of the drain pipes is indicated on drawing No. 10.

Elbows.

Terra cotta drain pipes.

The plumber is to provide and lay all the terra cotta pipes, and to complete the drainage to the entrance of the sewer.

All the stop cocks, draw cocks, traps, waste pipes, and other articles in connection with the plumbing, which may be necessary to a creditable and proper completion of the building, to be provided as may be directed by the engineer in charge of the work.

Miscellaneous.

Gas Pipes and Fitting.

Gas pipes to be furnished and laid throughout the building, of sufficient size to supply the annexed list of burners, in conformity to the rules and regulations of the Philadelphia Gas Company.

All the pipes to be laid so as to be easily got at for repairs, and to have such descents as will prevent the accumulation of water arising from condensation.

The pipes to supply the lights on the outside of the building to be separate from the general supply pipe, so as to admit of their being used independently of each other.

It is understood that the gas fixtures are not to be furnished by the party contracting for the gas pipe and fitting.

Gas fixtures not to be furnished by contractor.

The following is a list of the gas burners required throughout the building, the aggregate number being 313:—

In general waiting-room, 5 reflectors, each 8 lights.

In gentlemen's waiting-room, 2 reflectors, each 8 lights, and 4 brackets, each 2 lights.

In ladies' waiting-room, 2 reflectors, each 8 lights.

In restaurant, 4 reflectors, each 12 lights, and 8 brackets, each 2 lights.

In office of depot master, 1 pendant of 2 lights, and 2 brackets, each 1 light.

In gentlemen's water-closet-room, 1 reflector of 6 lights.

In ladies' water-closet-room, 1 pendant of 4 lights.

In baggage-room, 1 pendant of 4 lights.

In ticket office, 1 pendant of 2 lights, and 2 brackets, each 1 light.

In boiler room, 1 bracket of 1 light.

In pantry, 1 bracket of 2 lights.

In store pantry, 1 pendant of 2 lights.

In kitchen, 2 pendants, each 2 lights.

In back hall, 1 pendant of 2 lights.

In 9 offices, second story, each 1 pendant of 2 lights, and 2 brackets, each 1 light.

In 4 offices, second story, each 1 pendant of 4 lights, and 2 brackets, each 1 light.

In telegraph office, second story, 1 pendant of 4 lights, and 4 brackets, each 1 light.

In 4 rooms, second story, each 1 pendant of 2 lights.

In gallery of second story, 12 brackets, each 2 lights.

In 3 rooms in attic, each 1 pendant of 2 lights.

In 3 bed-rooms in attic, each 1 pendant of 2 lights.

On newel, 1 candelabra of 4 lights.

On front steps, 4 candelabras, each 5 lights.

Painting and Glazing.

All the exposed wood and iron work, *inside* and *outside*, usually painted in such buildings, to have *three* coats of pure white lead and linseed oil; grained as may hereafter be directed. All the exterior cornices, balconies, iron columns, capitals and bases, and all other exterior iron work to be primed with red lead and linseed oil, painted with three additional coats, consisting of white lead and linseed oil, and sanded in two coats, in the best manner, in imitation of the Ohio sand stone used in the building, excepting the cresting and the balcony railings, all of which will be painted with French blue, and tipped with the best gold leaf.

Graining. Sanding. Gilding.

All the windows and transom lights throughout the building to be glazed with the best American glass, well bedded, bradded and back puttied, and left clean and perfect on the completion of the work.

Glass.

The skylights in the roof to be made as shown on the several drawings, and glazed with English rolled glass three-eighths of an inch (⅜′) thick, laid in such a manner as to render them permanent, durable, and perfectly weather proof.

Skylights.

The number, dimensions and form of all the lights of glass throughout the building to be ascertained from the drawings.

Hardware.

The outside doors of the waiting rooms to have extra heavy bronzed store latches, such as are used by the Pennsylvania Railroad Company. The doors of the ticket office, the baggage-room, the restaurant and the telegraph office to have three-tumbler mortise night latches, with knobs only on the inside. The doors leading from the waiting-rooms to the water-closet rooms to have mortise latches two and a quarter by three and a quarter inches (2¼″×3¼) with porcelain furniture. The water closets to have rim latches and mineral furniture.

Latches.

The remaining doors throughout the building to have six inch (6″) tumbler locks, with bronze furniture for the *first* story, white por-

Locks.

celain furniture for the *second* story, and mineral furniture for the *third* story.

The windows of the ladies' private room to have ornamental wove wire screens. **Wire screens.**

All the double doors to have strong spring bolts, top and bottom. **Spring bolts.** Two clothes hooks of approved design will be required in each water-closet; **Clothes hooks.** also, such hat and coat hooks in the closets throughout the building as the engineer in charge may direct.

Heavy cast-iron butt hinges will be required for all the doors. **Hinges.** The inside shutters are to be hung on cast butts, and to have strong bronze shutter hooks and knobs. All the windows of the first story to have heavy bronze sash-fasteners.

All the hardware required in the building to be furnished of the most substantial and approved kind.

Tin Work.

The portions of the roof inside of the lines of cresting; **Roof.** also, the tops of the dormer windows, and the roofs of the kitchen and boiler-room, to be covered with first quality I. C. charcoal tin, Melyn braud, laid with cleat or lapped joints. The whole to be painted on the under side with one coat of metallic paint, and on top with two coats of Venetian red.

All the necessary gutters to be formed in the most approved manner, **Gutters.** and securely connected with the iron conductors for discharging the water from the building.

Slating.

The roofs of the tower and spires, and the steep portions **Slate.** of the roof of the building, to be covered with slate of different colors, ornamentally disposed, as indicated on the perspective view, subject to such modifications of design as the engineer in charge may hereafter direct.

Blue slate, from the Peach Bottom quarries, is to be used for the blue portions of the design, and *red* and *green* slate from Vermont, where these colors are indicated.

All the slatts to be laid on two thicknesses of roofing felt, **Roofing felt.** and secured with galvanized iron nails.

The whole to be executed in the best and most workmanlike manner, using galvanized iron flashings, and such other precautions **Flashings.** as may be necessary to make a perfectly water-tight roof.

(*Note.*) The portions of the roof embraced within the lines of cresting; also, the tops of the dormer windows and of the main tower, and the roofs of the boiler house and kitchen, will be covered with tin.

Heating.

The entire building will be heated by radiation from **Steam pipes.** steam pipes, which will be distributed as may hereafter be decided upon, it being understood that a sufficient radiating surface shall be provided to effectually warm the building in the coldest weather. The steam to be generated in the boiler-house.

General Conditions.

All the work to be done in the best and most workman like manner, of approved materials, according to these specifications and the plans and drawings, to be done and furnished, whether the same may have been herein particularly specified or not; and all such necessary work and materials, which may not have been set forth in these specifications, or indicated on the plans referred to, to be done and furnished in a manner corresponding with the rest of the work, as well, as truly, and as faithfully as though the same were herein particularly described, and specifically provided for.

Manner of executing the work.

Work and material not specified.

Every part of the building is to be executed under the direction, and subject to the approval of the Engineer in charge, who shall act as the agent and representative of the Engineer and Architect, to whom all questions relating either to the work, or to the contract for the same, shall be referred, and his decision shall in all cases be final.

Supplement.

The attention of bidders is called to the following points not mentioned in the above specifications:

First, In the contract for the building, it will be required and provided that the footways on Sixth Street be kept clear its full width, from the curb to the regulated line of the steps; that the materials used in the construction of the work shall not be deposited at all on Sixth Street; that the roadway and the sidewalk be kept clear of all incumbrance at all times, and that a temporary plank shed be placed over the said footway, for the protection of citizens during the progress of the work.

Second. All bids must be handed in on or before Saturday, July 5th, 1873.

Third. It is important to have the building roofed in, and the first story finished and ready for use by January 1st, 1874, and the whole work completed, finished up and delivered into the hands of the railroad company by June 1st, 1874. Bidders will please state whether they can accomplish the work within these dates, and if not how much longer time they would require.

Fourth. The columns in the restaurant are to be set on dressed stone plinths 1′ 6″ square and 1′ 2″ thick, and the iron floor beams are to be framed around them.

Fifth. All chamfered bricks are to be moulded.

Sixth. Six galvanized-iron ventilators to be constructed on roof, as shown on transverse section.

Seventh. A main water pipe of 3 inches in diameter for extinguishing fires, is to be carried up from the cellar to the third story, with a 2 inch hose attachment on each floor with screws and caps.

Eighth. The encaustic tiles provided for in the specifications to be from the manufactory of Maw & Co., London, their agents being Merchant &

Co., N. Y. The patterns are found in their printed catalogue, as follows: for the exterior walls of the building, No. 91, plate 36, and No. 178, plate 34. For the general waiting-room and the restaurant, No. 58, plate 15. For the hall and water-closet rooms, No. 223, plate 15, with the border shown on No. 58.

Ninth. The following portions of the work will be done and furnished by the railroad company, to wit: Gas pipes and fitting, and gas fixtures; terra cotta drain pipes and laying; steam heating and corking apparatus; plumbing; iron columns in the restaurant; curbing and paving.

Tenth. Bidders are requested to state what difference it would make in the cost of the work to finish all the first story in *hard woods*, oiled and polished, instead of *pine*, painted and grained.

For Masonry of Railroad Bridge Over Street.

SPECIFICATIONS

FOR MASONRY OF STREET BRIDGE TO BE ERECTED OVER THE PENNSYLVANIA RAILROAD, AT PENN AVENUE, IN THE CITY OF PITTSBURG, PENNSYLVANIA.

PENNSYLVANIA RAILROAD CO.,
OFFICE OF ENGINEER BRIDGES AND BUILDINGS,
No. 233 S. Fourth St., No. 8, third floor,
PHILADELPHIA, April 15, 1875.

See page 273.

Depth of foundation.

The foundations to be dug out to a depth of six feet below the natural surface of the ground, or to such greater depth if found necessary, as the engineer may decide, and to be filled in for the depth of three feet with concrete.

Concrete stone.

The concrete is to be formed of a hard durable stone, to be approved of by the engineer, broken into angular fragments of a size to pass through a two and a half inch ring, and to be screened.

Sand Cement.

This stone to be mixed with clear, sharp, river sand and hydraulic cement, one part sand and four parts broken stone. This must not be mixed in a larger amount than requires one barrel of cement at a time, and must be used as mixed, not being allowed to lay, and then remixed with water and used.

Mixing.

The concrete must be prepared by first spreading out the cement and sand in the proper proportions on a platform of rough boards, and thoroughly mixing them in a dry state. The proper quantity of stone is then to be added, and after again thoroughly mixing the whole, water is to be added as much as necessary, to bring the mass to the proper consist-

ency; the materials being mixed as the water is added, until all the materials are thoroughly incorporated, and the surface of each stone is well coated with mortar. This concrete must be placed in the foundations in layers not over a foot thick, and must be either thrown from a height of not less than ten feet, or else each layer must be well rammed until a film of water appears on the surface, but not enough to make it quake.

Time to set.

Time must be given for the concrete to become firm before masonry foundation is commenced upon it, as heavy pressure tends to retard the setting.

Masonry.

How laid.

The masonry will be rock range pitch face; the stone to be accurately squared, jointed, and bedded, and laid in courses not less than twelve inches thick, nor exceeding twenty-four inches in thickness; decreasing from bottom to top of pier or abutment. The stretchers shall in no case have less than sixteen inches bed; and for all courses above sixteen inches, at least as much bed as face. They generally shall be at least four feet in length. The headers shall be of similar size with the stretchers, and shall hold the size in the heart of the wall that they show on the face, and be so arranged as to occupy one-fifth of the face of the wall, and when the thickness of the wall will admit of their interlocking, they will be disposed in that manner. When the wall is too thick to admit of that arrangement, stones not less than four feet in length will be placed transversely in the heart of the wall to connect the two opposite sides of it. The stones for the heart of the wall will be of the same thickness as those in the face and back; bedded the same as the face stone, but not jointed, and must be well fitted to their places, any remaining interstices to be filled with small sound stones or chips. The face stones to be set in cement mortar; the interior stones to be laid dry, and every course to be thoroughly grouted. The proportion of sand, cement and lime in the mortar and grout, to be as directed by the engineer.

Bond.

Grouting.

Scabbled.

The stones forming the masonry will be generally left with their faces as they come from the quarry, unless the projection from the neat line should exceed two inches, in which case they shall be roughly scabbled down to that point.

Coping, &c., to be hammer dressed

Such coping and such posts for railing, as shall be indicated on the drawings, or shall be directed by the engineer, shall be hammer dressed to the required sizes, and placed as shown.

Quality of stone.

In all masonry the stone must be of a hard and durable quality, either Derry, Massillon, or Freeport, of good size and shape, to be approved of by the engineer.

Locality.

The coping, bridge seats and posts, being the hammer dressed work, are to be of the Massillon stone.

Use of lime and cement determined by Engineer.

Such portions of the masonry as the engineer may require to be laid in lime or hydraulic cement, to be so laid; the Pennsylvania Railroad Company furnishing, or paying for the lime or

cement used, and the contractor furnishing a suitable protection for the cement from the weather.

If, in the progress of the masonry, an increase in the number of headers specified should be required by the engineer, such additional number shall be laid in the work as he shall designate. Increase in number of headers.

The whole of the construction to be in strict accordance with the drawings furnished by the Engineer of Bridges and Buildings of the Pennsylvania Railroad Company, and under the direction of the engineer in charge of the work. Work to accord drawings.

Bidders will state the prices for which they will do the work in the following manner:— Bids.

For excavation of earth, so much per cubic yard, measured in the excavation.

For concrete, so much per cubic yard, measured in place; not including the cement and broken stones, which will be furnished by the Pennsylvania Railroad Company.

For masonry laid in place, so much per perch of twenty-five cubic feet.

For coping and bridge seats, so much per foot lineal of each width.

For posts, so much per post in place.

All prices to be for work measured in the wall complete.

The prices shall in every case include the furnishing of all materials, (except lime, cement, and broken stone for concrete, which will be furnished by the Pennsylvania Railroad Company,) the cost of scaffolding, etc., and all expenses attending the delivery of these materials, and all risks or any loss occasioned by floods, neglect or accident during the progress of the work, until the same shall have been completed, and accepted by the engineer.

JOSEPH M. WILSON,

Engineer Bridges and Buildings, Penna. R. R.

For Superstructure of a Wrought Iron Railroad Bridge.

SPECIFICATIONS

FOR SUPERSTRUCTURE OF RAILROAD BRIDGE TO BE ERECTED NEAR MORRISVILLE STATION, ON THE NEW YORK DIVISION OF THE PENNSYLVANIA RAILROAD.

PENNSYLVANIA RAILROAD CO.
OFFICE OF ENGINEER BRIDGES AND BUILDINGS,
No. 233 S. Fourth St., No. 8, third floor.
PHILADELPHIA, July 15th, 1875.

See page 273.

The superstructure is to be constructed on the triangular girder system, and to consist of four spans, square to the line of the railroad, three of them deck bridges of three trusses, and one a half-through bridge of two trusses, numbering from the west end, the railroad track having a curvature of five and a half degrees. General description

The trusses throughout are to be composed entirely of wrought iron, except rollers and bolster blocks on the piers and abutments, having wrought upper chords of channels and plates, wrought iron upset weldless link lower chord, and wrought iron braces, all with link ends to be upset without weld. All joints are to be made with pin connections, and sleeve nuts are to be introduced in the laterals and diagonals for adjustment.

The deck spans are to have timber floor-beams, and the half-through span wrought iron built cross girders; white oak track stringers are to be used throughout. The bolsters and abutment plates are to be of wrought iron.

The general dimensions are as follows:—

Span No. 1.

Distance, centre to centre of end pins	73 ft. 6 in.
Number of panels	4
Number of sub-panels	8
Length of each panel	18 ft. 4½ in.
Length of each sub-panel	9 ft. 2¼ in.
Height of truss, centre to centre of chords	7 ft. 3 in.
Distance, centre to centre of trusses	9 ft. 9 in.

Spans Nos. 2 and 3.

Distance, centre to centre of end pins	53 ft. 6 in.
Number of panels	4
Number of sub-panels	8
Length of each panel	13 ft. 4½ in.
Length of each sub-panel	6 ft. 8¼ in.
Height of truss, centre to centre of chords	6 ft. 6 in.
Distance, centre to centre of chords	9 ft. 6 in.

Span No. 4.

Distance, centre to centre of end pins	57 ft. 6 in.
Number of panels	6
Number of sub-panels	12
Length of each panel	9 ft. 7 in.
Length of each sub-panel	4 ft. 9½ in.
Height of truss, centre to centre of chords	5 ft. 9 in.
Distance, centre to centre of trusses	26 ft. 6 in.

In the fourth span the cross girders occur at every sub-panel.

Wrought Iron.

All the wrought iron must be of the best quality, tough and fibrous, free from flaws and cracks along the edges. All the iron in the tensile members, lower chords, tension diagonals, laterals, bolts, &c., must be double rolled from the muck bar direct, no scrap will be allowed, and must be capable of sustaining an ultimate stress of sixty thousand (60,000) pounds per square inch, on a turned-down or grooved section, with no permanent set under twenty-five thousand (25,000) pounds per square inch. When tested to breaking, if so required by the Engineer, the links and rods must part through the body, and not at the pin hole in the head.

All workmanship must be first-class. All abutting surfaces must be planed or turned, so as to insure even bearings, and protected by white lead and tallow before shipment. No error of over one sixty-fourth ($\frac{1}{64}$) of an inch will be allowed in the lengths of bars between centres of pin holes of over one one-hundredth ($\frac{1}{100}$) the diameter of the pin; said holes to be accurately drilled. All riveted plates must come in close contact where abutting, and the rivet holes must be spaced accurately and truly opposite. Rivets must completely fill the holes and have full heads, and, when necessary, they must be countersunk. Thickening washers are to be used whenever required to make the joints perfectly snug and tight.

Castings.

The cast iron work is to be true and sound, free from flaws and defects of any kind, and may be green sand castings, but should be of good tough iron, the lines sharp and clear and according to the drawings.

No rough or crooked castings will be accepted. All bolt and pin holes must be accurately drilled: all abutting surfaces must be planed, if necessary, to insure even bearings and neat close fittings, and the castings are to be perfectly dressed and fitted up to make a good job generally, when put in the bridge.

General conditions

The whole of the construction to be in strict accordance with the drawings furnished by the Engineer of Bridges and Buildings of the Pennsylvania Railroad Company. In all cases figures are to be taken in preference to any measurements by scale. No alteration to be made unless authorized by the Engineer. All work to receive one coat of red lead in oil before being sent to the site.

Form of Bids.

Bidders will state the prices per pound for wrought and cast iron separately, delivered loaded on cars at the nearest point on the line of the Pennsylvania Railroad, or its branches, to their works; the point being designated in the bid. Any bidders prepared to perform erection will

also state a bid for erection at a round sum, the Pennsylvania Railroad Company transporting all materials from the place of delivery to the bridge site, and unloading the same, and also furnishing timber for false works, and timber for permanent roadway, the contractor, however, erecting the whole.

The approximate quantities of iron in the bridge will be as follows:— Quantities.

Wrought Iron.	
Bar iron	79,600 lbs.
Channels	49,400 "
L and T iron	5,000 "
Plates	58,300 "
Rivets, ferrules, &c.	9,000 "
	201,300 lbs.
Cast Iron	4,000 "
	205,300 lbs.

JOSEPH M. WILSON,
Engineer Bridges and Buildings Penna. R.R.

For Masonry of Bridge at Girard Avenue, Philadelphia.

SPECIFICATIONS

FOR MASONRY OF STREET BRIDGE OVER THE PENNSYLVANIA RAILROAD AT JUNCTION OF BELMONT AND GIRARD AVENUES.

PENNSYLVANIA RAILROAD CO.
OFFICE OF ENGINEER BRIDGES AND BUILDINGS,
No. 233 S. Fourth St., No. 8, third floor.
PHILADELPHIA, Aug. 16, 1875.

See page 273.

A new north abutment is to be built, and also piers for rows of columns between the railroad tracks, the present north abutment to be entirely removed by the party contracting, who can make use of the stone in the same for the new work. The contractor is to perform his work without interfering with the travel on Belmont avenue, and is to preserve for the use of the passenger railroad companies at least one street track. Special care must be taken with the water pipe now in the street, that it is properly tresteled up and firmly supported from the beginning to the end of the work. The exposed side of the street next to any excavations that may be made, to be properly protected by temporary fencing, and the contractor is to be responsible for any accidents that may occur by reason of insufficient protection for the public. He is also to be responsible for any accidents that may occur to the water pipe for want of proper

Description of the work with general instructions.

supports, and he is to provide and erect all necessary shoring for the proper protection of banks, property, buildings, &c.

The excavations to be made to a depth of six (6) feet below the surface of the ground, or to such greater depth as may be found necessary to insure a good foundation. Excavation.

The foundations to be rubble masonry, of stone of an approved quality and shape, the general size of which shall not be less than eight (8) cubic feet. Foundations.

The masonry above ground to be built of Trenton or other approved stone, and to be rock range pitch face, without margin draft and built to the specified batters. The face stone to be accurately squared, jointed and bedded, and laid in course not less than twelve (12) inches nor exceeding thirty (30) inches in thickness, decreasing from bottom to top of abutment. They must be laid on their natural beds. The vertical joints in each course must be so arranged that they shall not come closer to those of a superior or inferior course than by one (1) foot. All courses to be dressed for a three-eighths ($\frac{3}{8}$) joint. The stretchers shall in no case have less than sixteen (16) inches bed; and for all courses above sixteen (16) inches, at least as much bed as face. They generally shall be at least four (4) feet in length. The headers shall be of similar size with the stretchers and shall hold the size in the heart of the wall that they show on the face, and be so arranged as to occupy one-fifth ($\frac{1}{5}$) of the face of the wall, and when the thickness of the wall will admit of their interlocking, they will be disposed in that manner. When the wall is too thick to admit of that arrangement, stones not less than four (4) feet in length will be placed transversely in the heart of the wall to connect the two opposite sides of it. The backing stone shall be of large size and have parallel beds, but the beds are not required to be dressed like the face stone. The backing stones shall be laid so as to break-joint, and must be well fitted to their places, any remaining interstices to be filled with small, sound stone or chips. When the thickness of the wall exceeds three and one-half ($3\frac{1}{2}$) feet, headers of the same dimensions as those in the face, and in equal number, will be placed in the back of the wall. The face and back stones to be set in cement mortar; the inferior stones to be laid dry and every course to be thoroughly grouted. The proportion of sand, cement and lime in the mortar and grout to be as directed by the engineer. Neat work.

The stones forming the masonry will be generally left with their faces as they come from the quarry, unless the projection above the neat line should exceed two (2) inches, in which case they shall be roughly scabbled down to that point.

Such portions of the abutments and piers as are shown by the drawings will be capped by coping stones of the thickness, projection and amount of dressed work as may be specified thereon, and particular care must be taken that the elevations of the tops of copings shall be the same as required by

the drawings, and any change in the thickness of courses, or any rebuilding that may be required to attain the elevation, shall be so done.

The pedestals specified on drawings must be neatly and accurately dressed. The stone to be free from unsightly flaws, cracks, clay or other marks, and any that the engineer shall deem to be such shall cause the rejection of the piece. The pedestals to be placed in such position and at such elevation as the drawings shall require.

The workmanship throughout shall be of the best quality for each of the portions above specified, and any portion that may be deemed unsatisfactory or incorrect shall be rebuilt.

Any additions to this work, when of the same kind as the work above specified, shall be done at the same rate as that already in hand, and any modifications that may be made to the plans, or any increase in the number of headers that may be specified shall be so made without additional charge.

Such portions of the masonry as the engineer may require to be laid in lime or hydraulic cement shall be so laid; the Pennsylvania Railroad Company furnishing or paying for the lime or cement used, and the contractor providing a suitable protection for the cement from the weather.

The whole of the construction to be finished up complete in accordance with the drawings and these specifications, and subject to the approval and acceptance of the Chief Engineer and Surveyor of the City of Philadelphia.

Forms for bids of masonry.

Bidders will state the prices for which they will do the work, in the following manner:

For excavation of earth, so much per cubic yard, measured in the excavation.

For foundations laid in place, so much per perch of twenty-five (25) cubic feet.

For neat work masonry above foundations laid in place, so much per perch of twenty-five (25) cubic feet.

For copings, so much per lineal foot.

For pedestals, and cap stones for piers, so much per pier in place.

The bidder will state what kind of stone he proposes using, and the time in which he will do the work. He will also state the price per perch of twenty-five (25) cubic feet that he will pay for the masonry in place, of the present north abutment.

All prices to include the items in their proper positions in the work, and all cutting and setting that may be required, also the furnishing of all materials (except lime and cement, which will be furnished by the Pennsylvania Railroad Company), the cost of scaffolding, &c., and all expenses attending the delivery of these materials, and all risks or any loss occasioned by floods, neglect or accident during the progress of the work, until the same shall have been completed and accepted by the engineer.

The Pennsylvania Railroad Company to furnish all bolts and iron that may be required to be set in the stone work.

The price for excavation will also include the refilling of any of the excavated material around the finished work, and back of it on Belmont avenue up to the grade of the street, and the removal of all surplus, refuse, and rubbish that may accumulate during the progress of the work, from the premises.

JOSEPH M. WILSON,

Engineer Bridges and Buildings, Penna. R. R.

SPECIFICATIONS

FOR GRADING SECTION 4, "FALLS" DRIVE.

Proposals will be received till noon of Thursday, July 31st, 1873, at the Office of the Commissioners of Fairmount Park, 251 S. Fourth St., Phila., for Grading Section 4 of "Falls" Drive.

"Falls" Drive is on the East bank of the Schuylkill River, and section 4 extends from Falls wooden bridge, north-west, to the public street that leads to Ridge avenue, at Wolfenden's corner. Length 1125 feet; width of roadway, 30 feet.

The work comprises some clearing and grubbing; about 12,000 cubic yards of borrowed earth embankments; about 1,300 cubic yards of clean coal ash surfacing to road-way; some wooden trunk drains, and possibly some excavation and rubble masonry.

The contractor shall furnish all tools, and as directed by the engineer; shall do the grubbing and clearing, make the excavations and embankments, furnish and deliver from outside of the Park the borrowed earth—properly form the road-way, gutters, borders and slopes, and do all work necessary to open section 4 of "Falls" Drive to public use, except constructing the wooden trunk drains, which will be furnished by the Park, but the contractor shall make all necessary excavations, and put the drains in place.

Should temporary drains and bridges be required during construction, the contractor shall, at his own expense, supply them.

The engineer will mark trees and stumps to be removed, and indicate the places to which the contractor shall deliver the same. Care shall be taken that no other trees or shrubs are injured or disturbed.

All work shall conform to the lines, grades and limits fixed by the engineer.

No top soil or perishable material shall be placed within the limits of the road-way, and all borrowed earth shall be free from offensive matter and rubbish, and in every way acceptable to the engineer.

The borders and tops of the slopes shall be formed of earth suitable for planting. The road-way shall be reduced to sub-grade (one foot below finished grade), and when time has been allowed for settlement, shall be re-

dressed with earth to sub-grade, and covered with one foot in depth of clean coal ashes, and dressed to the proper form and height for the finished surface.

Grading of material excavated within the limits of the Park, shall be estimated in cubic yards of excavation only, and the price hereinafter named for excavation shall include excavating, delivering and forming into embankments.

Borrowed earth required to complete the embankments shall be furnished by the contractor from outside of the Park limits, and the contractor shall deliver and form the same into the road embankments.

The quantity will be estimated in cubic yards in the embankments formed of such borrowed earth, and after the same have thoroughly settled, and will be paid for at the rate hereinafter named for borrowed earth, which rate includes compensation for furnishing, delivering and forming into embankments.

The coal ashes shall be free from all rubbish and foreign material, and shall be spread uniformly on the road surface, from the bank side of one gutter to the bank side of the opposite gutter, and shall fill the one foot in depth space between sub-grade and finished grade.

Before coal ashes are put on any portion, the shaping and sub-grading of the same must be approved by the engineer, and any settlement after the ashes have been put on shall be filled with similar ashes and made good by the contractor, at his own expense.

The quantity of coal ashes will be estimated in cubic yards in the roadway, but any excess in depth over one foot shall not be paid for except as borrowed earth. The price hereinafter named for coal ashes shall include compensation for furnishing, delivering, cleaning, spreading and forming the road surface.

Upon the completion of the work the contractor shall carefully finish and dress to the form required the surface of the road, borders, slopes, and all Park areas entered upon.

Damage to the work from high water, or any cause before its final completion, shall be made good by the contractor at his own expense.

Accidents resulting by reason of the work will be at the risk of the contractor, who shall erect and maintain proper guards to protect the public.

The Contractor shall keep constantly on the work at least one foreman; shall commence operation on or before August 18th, 1873. Shall prosecute the work continuously and regularly, at a rate that will complete the whole on or before November 1st, 1873, and shall so complete the same.

Estimates will be made monthly, reserving twenty per centum till completion.

No proposal will be considered unless accompanied by a properly executed and satisfactory bond, in the sum of $1000, to secure the faithful execution of the work, should the proposal be accepted.

The right to reject any or all bids is reserved.

Specifications

For Macadamizing Belmont Avenue, Fairmount Park, Phila.

The area to be macadamized is about eighteen feet wide, and two thousand five hundred feet long, extending from Lansdowne drive to Elm avenue, and comprising about five thousand square yards. Adjoining the Macadam, on each side, there is to be a gutter thirty inches wide, paved with Belgian blocks.

The forming and compacting of material to sub-grade, suitable to receive the Macadam, will be made by the Park force, independent of the contract for Macadamizing, but any disturbance of this sub-grade shall be repaired before the Macadam is laid, or at the expense of the Contractor.

All material shall be furnished by the Contractor—shall be approved by the Engineer—and shall be of a durable and uniform quality. The Macadam may be formed of selected furnace cinder, or of approved stone. But the Contractor must state in his proposal what material he will use, and from whence obtained.

The Macadam shall be twelve inches deep,* put on in layers as follows:—The lower course shall be of irregular blocks, not exceeding five inches in their longest diameter, placed compactly together, and covered with the same broken to pass through a three-inch ring, and distributed to form an even surface, parallel to and five inches below finished grade. The surface thus formed shall be thoroughly rolled, then covered with similar material broken to pass through a screen with two-inch mesh, and distributed to form a surface parallel to and one inch below finished grade. This surface shall be thoroughly rolled, then covered to finished grade, with similar material broken to pass through a screen with one and one quarter inch mesh, and thoroughly rolled again. No dirt or ashes, and no material of any kind that will pass through a screen with one half inch mesh shall be introduced into or upon the Macadam. All rolling shall be done with a roller weighing not less than one gross ton per foot in length of bearing surface of roller.

For gutters, sub-grade shall be twelve inches below finished grade. The lower five inches shall be of similar material to the lower course of the Macadam. This shall be rammed, covered with clean gravel, and finished with a pavement of rectangular blocks of granite or trap rock. The said stone blocks are to be of durable and uniform quality, each measuring on the face or upper surface, not less than four nor more than eight inches in length, and not less than four nor more than six inches in width, and in depth not less than four or more than seven inches; blocks of four inches in width on their face, to be not less than three inches in width at base; all other blocks in transverse measurement on the base, to be not more than

* The traffic is generally light on this portion of the Avenue.

two inches less than on the face; but no block on the base shall be of less width or length than three inches.

The contractor shall, on all work, follow and finish to the lines, grades and forms of section, given by the Engineer in charge. He shall erect and maintain proper guards to protect the public from accident; and must, at all times, keep a sufficient portion of Belmont Avenue unobstructed, as to satisfy the demands of travel and traffic. Shrinkage, or settlement, or damage from whatever cause, before the completion of the whole work, shall be repaired and made good by or at the expense of the Contractor.

Payments will be made monthly, by warrants drawn on the City Treasurer, based upon estimates of the Engineer in charge, reserving twenty per centum until the completion of the contract.

The lower course of the Macadam, called for in these Specifications, shall be completed on or before the 10th day of December, A. D., 1870, and the whole amount shall be completed on or before the 23d day of December, A. D. 1870.

Specifications

For Graduation and Masonry of a Single Track Railroad.

Form used by the Pennsylvania, and Philadelphia & Reading Railroads.

See pages 232, 280.

Graduation.

Under this head will be included all excavations and embankments required for the formation of the road-bed; cutting all ditches or drains about or contiguous to the road; the foundations of culverts and bridges, or walls; the excavations and embankments necessary for reconstructing turnpike or common roads, in cases where they are destroyed or interfered with in the formation of the Railroad; and all other excavations or embankments connected with or incident to the construction of said Railroad.

All cuttings shall be measured in the excavations and estimated by the cubic yard under the following heads, viz: *Earth, Loose Rock, Solid Rock.*

Earth—will include clay, sand, loam, gravel, and all other earthy matter, or earth containing loose stone or boulders intermixed, which do not exceed in size three cubic feet.

Loose Rock—shall include all stone and detached rock lying in separate and contiguous masses, containing not over three cubic yards; also, all hard-pan, cemented clay, or stone, slate or other rock that can be quarried without blasting, although blasting may be occasionally resorted to.

Solid Rock—includes all rock occurring in masses exceeding three cubic yards, which cannot be removed without blasting.

The road-bed will be graded twenty-one feet wide in earth cuttings, and sixteen in fillings, except where otherwise directed by the Engineer, with side slopes of such inclination as the Engineer shall in each case designate, and in conformity to such depths of cuttings and filling as may have been or may hereafter be determined upon by said Engineer.

Earth, gravel, and other material taken from excavations (except when otherwise directed by the Engineer) shall be deposited in the adjacent embankment, the cost of removing which, when the haul is not more than sixteen hundred feet, will be included in the price paid for excavation; all material necessarily procured from without the road, and deposited in the embankments, will be paid for as embankment only, but all material necessarily procured from within the line of the Railroad, and hauled more than sixteen hundred feet, will be paid for as excavation, and also as embankment. In procuring materials for embankment from without the line of road, the place will be designated by the Engineer in charge of the work, and in excavating and removing it, care *must* be taken to injure or *disfigure* the land as little as possible. The embankment will be formed in layers of such depth, and the materials disposed and distributed in such manner as the Engineer may direct, with the required allowance for settling.

Material necessarily wasted from the cuttings will be deposited in the vicinity of the road, according to the directions of the Engineer in charge.

The ground to be occupied by the excavations and embankments, together with a space of 12 feet beyond the slope stakes on each side, or 10 feet beyond the berm ditch, where one is required, will be cleared of all trees, brush, and other perishable matter. Where the filling does not exceed two and a half feet, the trees, stumps, and saplings must be grubbed; but under all other portions of the embankment it will be sufficient that they be cut close to the earth. Where the road passes through woods, the timber on each side of the road to be slashed for such a width (generally 80 feet from the centre line) as the Engineer may direct.

Contractors, when directed by the Engineer in charge of the work, will deposit on the side of the road, or at such convenient points as may be designated, any stone or rock that they may excavate, and if, in so doing, they should deposit material required for embankment, the additional cost, if any, of procuring other materials from without the road, will be allowed. All stone or rock excavated and deposited as above, together with all timber removed from the line of the road will be considered the property of the Railroad Company, and the contractors upon the respective sections will be responsible for its safe keeping until removed by said Company, or until their work is finished.

The line of road or the gradients may be changed, if the Engineer shall consider such change necessary or expedient, and for any considerable alterations, the injury or advantage to the contractor will be estimated, and such allowance or deduction made in the prices as the Engineer may deem just and equitable; but no claim for an increase in prices of excavation or em-

bankment on the part of the contractor will be allowed or considered, unless made in writing, before the work on that part of the section where the alteration has been made shall have been commenced. The Engineer may also, on the conditions last recited, increase or diminish the length of any section for the purpose of more nearly equalizing or balancing the excavations and embankments.

Whenever the route of the Railroad is traversed by public or private roads commodious passing places must be kept open, and in safe condition for use; and, in passing through farms, the contractor must also keep up such temporary fences as will be necessary for the preservation of the crops.

Masonry.

All masonry will be estimated and paid for by the perch of twenty-five cubic feet, and will be included under the following heads, viz: *Culvert Masonry, Bridge Masonry, Vertical and Slope Wall Masonry, and Paving.*

All rectangular culverts will be built dry, with a water way of not less than two and a half by three feet; the abutments will rest on a pavement of stone, set edgewise, of at least ten inches in depth, confined and secured at the ends by deep curb stones which must be protected from undermining by broken stone, placed in such quantity and position as the Engineer may direct. The abutment walls will not be *less* than two and a half feet thick, and built of good-sized and well-shaped stone, properly laid and bound together by stones, occasionally extending entirely through the walls. The upper course to have at least one-half of the stones headers; and the stretchers in no case to be less than twelve inches wide: no stone in this course to be less than six inches thick. The covering to be of sound, strong stone, at least twelve inches thick, and to lap its whole width not *less than* ten inches on each abutment. The thickness of the covering-stone and dimensions of the walls to be increased at the discretion of the Engineer.

The foundations of these culverts, when the bottom of the pit is common earth, gravel, &c., will generally consist of a pavement formed of stone set edgewise, not less than *twelve* inches in depth, secured in the same manner as before described for rectangular culverts. When the foundation upon which a culvert is to be built is soft and compressible, and where it will at all times be covered with water, timber well hewed, and from eight to twelve inches in thickness (according to the span of the culvert), will be laid side by side crosswise upon longitudinal sills, and where a strong current will be forced through during floods; three courses of sheet piling are to be placed across the foundation: one course at each end and one in the middle, to be sunk from three to six feet below the top of the timber, according as the earth is more or less compact. The abutments are to be built of range work or in broken courses, the face stones bedded and jointed; the stretchers in the face are to have *beds* of at least 15 inches, and in no case less bed than rise, and they are to be not less than two feet long, measured in the face of the wall; the headers will extend through the wall in cases

where it does not exceed three and a half feet thick, and they shall have not less than 18 inches length of face. There shall be not less than one header to every seven feet of face, measured from centre to centre, and so arranged that a header in a superior course shall be placed between two headers in the course below; the backing stones shall be of large size, and have parallel beds, laid so as to break joints with one another, and when the thickness of the wall exceeds three and a half feet, headers of the same dimensions as those in the face will be placed in the back of the wall, in the proportion of one for every two headers in the face. The beds and joints of the arch stone are to be accurately cut, and to be laid in courses throughout. The ring stone will be neatly cut, and composed of alternate long and short bond stones of not less than three feet and eighteen inches respectively. The parapet and wing walls will be built similarly to the abutments, and surmounted with a well-dressed coping, not less than ten inches thick, and three feet wide. The outside stones to be laid in cement mortar, and the whole wall thoroughly grouted. The spandrel backing to be good rubble work, built as directed by the Engineer.

When rock foundation cannot be had for abutments and piers, the masonry shall be started upon hewn timber, sunk to such a depth as to protect it from decay, and to prevent the possibility of underwashing. The timber platforms will be composed of one or more courses, according to the depth of the water, the height of the masonry, or other circumstances, of which the Engineer shall judge and determine. The masonry will be of three qualities, either to be adopted at the *discretion* of the Engineer. First quality will be rock range work. The stone to be accurately squared, jointed and bedded, and laid in courses not less than twelve inches thick, nor exceeding twenty-four inches in thickness, regularly decreasing from bottom to top of pier or abutment. The stretchers shall in no case have less than sixteen inches bed for a twelve-inch course, and for all courses above sixteen inches at least as much bed as face; they shall generally be at least four feet in length. The headers will be of similar size with the stretchers, and shall hold the size in the heart of the wall that they show on the face, and be so arranged as to occupy one-fifth of the face of the wall; and they will be similarly disposed in the back. When the thickness of the wall will admit of their interlocking, they will be disposed in that manner. When the wall is too thick to admit of that arrangement, stones not less than four feet in length will be placed transversely in the heart of the wall, to connect the two opposite sides of it. The stone for the heart of the wall will be of the same thickness as those in the face and back, bedded the same as the face stone, but not jointed, and must be well fitted to their places; any remaining interstices will be filled with small sound stones or chips. The face stones to be set in cement mortar, the interior stones to be laid dry, and every course to be thoroughly grouted. The proportion of sand, cement and lime, in the mortar and grout, to be as directed by the Engineer. The stones forming the points of piers which act as ice breakers, shall be neatly

dressed on their faces; the other face stones will, with the exception of the draft, be generally left with the face as they come from the quarry, unless the projections above the draft should exceed two inches, in which case they shall be roughly scabbled down to that point. The abutments and piers, or such portions of them as the Engineer may direct, shall be covered with a course of coping, not less than twelve inches thick, well dressed and fastened together with clamps of iron.

The second quality of bridge masonry will be range work, or in broken courses, as may best suit the stone that is used. The face stones to be accurately jointed and bedded. The stretchers in the face to have beds of at least fifteen inches, and in no case less bed than rise, and to be not less than two and one-half feet long, measured in the face of the wall. The headers shall have not less than eighteen inches length of face, and shall extend at least three and one-half feet into the wall. There shall be not less than one header to every seven feet of face measured from centre to contre, and so arranged that a header in a superior course shall be placed between two headers in the course below. No course to be less than eight inches in thickness. The backing stone shall be of large size, and have parallel beds, but the beds are not required to be dressed as in first-class masonry. The backing stones shall be laid so as to break joint with one another, and when the thickness of the wall exceeds three and one-half feet, headers of the same dimensions as those in the face, and in equal number, will be placed in the back of the wall. The outside stones to be set in mortar, and the whole thoroughly grouted.

The third quality of bridge masonry will be rubble work, laid with mortar in irregular courses, and will consist of stone containing generally six cubic feet each, so disposed as to make a firm and compact work; and no stone in the work shall contain less than two cubic feet, except for filling up the interstices between the large blocks in the heart of the wall; at least one-fifth of the face shall be composed of headers extending full size four feet into the wall, and from the back the same proportion and of the same dimensions, so arranged that a header in the back shall be between two headers in the face. The corner-stones shall be neatly hammer dressed, so as to have horizontal beds and vertical joints.

The vertical walls will be good dry rubble work, of such dimensions, and built with such batter as the Engineer may direct. Slope walls will be built of such thickness and slope as may be required by the Engineer. No stones, however, to be used in its construction which do not reach through the wall, nor any less than six inches in thickness, by twelve inches long; the beds of the stones to be placed at right angles with the face of the bank; the joints must be close, and free from spalls.

In all masonry the stone must be of a hard and durable quality, of good size and shape, to be approved of by the Engineer. Such portions of the masonry as the Engineer may require to be laid in lime mortar or hydraulic cement, will be so laid; the Railroad Company furnishing or paying for the

lime and cement used. If, in the progress of the masonry, an increase in the number of headers specified should be required by the Engineer, such additional number shall be laid in the work as he shall designate.

The price per perch paid for masonry shall in every case include the furnishing of all materials (except lime and cement). The cost of scaffolding, centering, &c., and all expenses attending the delivery of these materials, and all risks from floods or otherwise.

Where the excavation of the road bed does not furnish sufficient stone for the protection of walls and embankments, the same shall be procured at such places, and disposed in such manner as the Engineer may direct.

No charge shall be made by the contractor for hinderances or delay, from any cause in the progress of any portion of the work in this contract, but it may entitle   to an extension of time allowed for completing this work, sufficient to compensate for the detention, to be determined by the Chief Engineer, provided he shall give the Engineer in charge immediate notice in writing, of the cause of the detention.

Nor shall any claim be allowed for extra work, unless the same shall be done in pursuance of a written order from the Engineer in charge, and the claim made at the first settlement after the work was executed, unless the Chief Engineer, at his discretion, should direct the claim, or such part as he may deem just and equitable to be allowed.

Specification

For Superstructure and Track Laying.

(From Vose's "Manual for Railroad Engineers.")

Superstructure.—Subsills.

To maintain the track in good adjustment until embankments are settled, subsills will be laid on certain banks, and likewise in cuts where the imperfect nature of the bottoming may, in the opinion of the engineer, render them expedient. These subsills to be fairly bedded in the earth, or ballasting, and carefully adjusted and rammed so as to correspond with the grade lines given by the engineer. An additional piece of sill four feet long shall be laid at each joint of the subsill, either under the sill, or alongside, as may be directed. The sills will be of 3×9 planks, in lengths of twelve, fifteen, eighteen and twenty-one feet; of which one-fourth may be below fifteen, one-fourth below eighteen, and one-fourth below twenty-one feet. The plank must be square at the ends, and of sound, durable material, and not have more than two inches wane on one end only. There will be about 25,000 feet, board measure, laid per mile where it may be required, and 660 joint sills, 3×9 inches, and four feet long. When the depth of stuff to be

moved to admit the subsills exceeds six inches, an allowance shall be made for extra labor, the amount of which shall be noted by the assistants on their receiving notice of such extra labor from the contractor or his agent.

Cross Ties.

The cross ties shall be of white, black, or yellow oak, burr oak, chestnut red elm, or other sound timber of suitable character, in the opinion of the engineer, eight feet long, and not more than three inches out of straight, hewn to a smooth surface on two parallel plane faces, six inches apart, the faces being not less than seven inches wide, for at least half that number, and the remainder not less than six inches wide. The ties shall be carefully and solidly laid on the subsills, or ballasting, or earth previously properly prepared, so as to give the true planes required by the rails, whether on straight or curved lines. They shall be laid at the rate of eight ties to each eighteen feet rail. All imperfect ties shall be excluded by the track-laying party. The surface of the ties to be faithfully adjusted to the grades given, and to the web of the rail; and the rail to be truly laid and firmly spiked, so as to correspond neatly to the alignment of the road. There will be about 2,500 ties required per mile of road.

Chairs and Joints.

When chairs are used, they shall be such as directed by the engineer and furnished by the company, and shall be well and accurately placed, and spiked in such manner and position as required, and the largest ties shall be selected for the joints. When the joint is made by fishing, there will be no tie directly under the joint.

*Rails.**

The rails will weigh about sixty pounds per lineal yard. No rail shall be laid on the tangents which is in any way twisted or bent. It shall be the duty of the first party to correct and make true any crooked rails received by him, also to bend to the proper curve, and in such manner as not to affect the strength of the bar, all rails laid in curves. Punching of rails, and cutting, will also be done by the contractor.

Track Laying.

The materials composing the track will be furnished by the company, and shall be laid in the best manner, according to the conditions following: The track will be laid on cross ties, and the ties at the proper places on subsills. Where the sills are used, they will be laid with four feet blocks at the joints, and with six feet blocks at the rail joints, the whole being set to their places by stakes, and by the engineer's directions, and mauled down to a perfect bearing, being settled at least half an inch by mauling. The cross ties will be placed uniformly distant, (twenty-eight inches from centre to centre). A slip of metal shall be inserted at the rail joints, while laying,

* See Specifications of Cincinnati Southern Railroad.

to keep the rails apart sufficiently to allow for expansion, which thickness (depending upon the temperature) shall be fixed by the engineer.* Two spikes shall be used at each end of tie, one inside and one outside of the rail, upon straight lines. Upon curves of less than 1,500 feet radius two spikes outside and one spike inside the rail, at each end of the tie, shall be used. Upon curves the outer rail will be raised to such an amount, depending upon the radius of the curvature, as the engineer may direct.

Turnouts.

The contractor to put in such turnouts and sidings, with the necessary frogs and switches, as may be required; the frogs and switches to be firmly and truly placed in position so as to work easily.

Filling and Ditching.

The stuff moved in bedding the sills and ties, to be placed between the latter. The ditches to be properly cleaned out after the track is laid; the filling never to rise higher than the top of the cross ties. Any surplus stuff to be moved out of the cuts, or if on embankments, to be thrown over the bank, leaving the track and road-bed in a neat and workmanlike manner.

Delivery of Materials.

The ties and sills to be delivered at some point on the road, as near as possible to the places, where they are to be used, in no case requiring more than one thousand feet of haul; to be so piled as easily to be counted and inspected. The bids for ties will be by the piece, the proposal stating the number and conditions; the sills to be bid for by the thousand, board measure. All material furnished in connection with track laying, to be delivered in such manner and time as to comply, in good season, with the contract for laying the rails.

Measurement of Track.

The measurement of track laid shall include the turnouts, measuring from heel to heel of switch, no extra allowance being made for putting in frogs or switch machinery.

Fencing.

Bids for fencing will be by the running foot or mile, including both sides of the road. Where required, it will consist of posts placed eight feet apart from centre to centre, set three feet in the ground, either by digging, or boring, and not by mauling. The posts shall be of oak, elm, chestnut, or other durable wood, not less than eight inches in diameter at the bottom, barked and charred where put into the ground. The boards to be 6×1 inches, and to square sixteen feet long, to be placed six inches apart, vertically, and fastened to the posts by tenpenny nails at each bearing and breaking joint with each other. The fence will be five bars high, the top of

* The expansion of wrought iron is .0000068 of its length for each degree Fahrenheit.

the uppermost being five feet from the ground. In side hill, and on ground liable to slide, particular care shall be taken to place the posts firmly in the ground. At cattle guards, the fence will be turned in to the proper distance, and such arrangement made as to prevent the passage of animals.

General Provisions.—Classification.

The classification of material excavated will be referred to the engineer, in all cases where the nature of the material is questioned, and his judgment taken thereon; also all material used in structures will be submitted to the inspection of the engineer or his assistants.

Quantities and Qualities approximate.

The quantities and qualities of work presented in the schedule are merely approximate, and the information given on the maps and profiles in relation thereto is according to the best present knowledge. The company retains the right to change at any time during the progress of the work the alignment, grades and widths of the road, or any part thereof, and also the limits of the sections; or to alter the character, vary the dimensions, or change the location of structures, or substitute one kind of work or material for another, or to omit entirely, when found necessary, or to require to be built where not now contemplated; and the contractor shall carry into effect all such alteration when required, without the contract prices being thereby affected, unless the aggregate value of all work contemplated by the contract be changed fully 20 per cent., in which case a fair allowance, either for the company or contractor, shall be made by the engineer. In case, however, the aggregate value of the work be changed over 20 per cent. of the original amount, and the contractor be not satisfied with the altered compensation, then said contractor may throw up said contract, on condition, that within ten days after receiving notice from the engineer of such alteration, he give written notice to the engineer or the company of his desire to do so, in which case, as in other cases of throwing up the contract, he shall, as soon as desired, give peaceable possession to the company or their agents, leaving also in their possession any tools or machinery upon which they have advanced anything; and the company may then settle with the contractor on the measure of damages which either shall suffer.

Basis for Estimating Effect of Changes.

The basis for estimating changes as above mentioned is understood to be the schedule exhibited at the letting.

No Liquor, and Good Order.

The contractor shall not sell, or allow to be sold or brought within the limits of his work, any spirituous liquors, and will in every way discountenance their use by persons in his employ. He will do all in his power by his own act, or by assisting the officers of the county, or of the corporation, to maintain the laws and such regulations as conduce to good order and

peaceable progress, and prevent encroachment on the rights of persons or property; and he shall discharge from his service, when required by the engineer, any disorderly, dangerous, insubordinate, or incompetent person, and refuse to receive into his employ any who may have been discharged for such cause from other parts of the work.

Monthly Estimates.

Measurements and estimates shall be made by the engineer, once in each month, by means of which may be known approximately the amount of work done, and the contractor shall be entitled to payment therefor, at such rates below his contract price as may be agreed upon by the parties to the contract; it being understood that the contractor has no claim on account of any material not laid in its place in the roadway, or for labor bestowed thereon; and the quantities shall be estimated from the dimensions when so laid, though, on the advice of the engineer, advances may be made on such material when delivered for use, in which case it becomes the property of the company, in the contractor's care and keeping, and he becomes liable for its loss or injury.

Extra Work.

No claim for extra work, or for work not provided for in the contract, shall be allowed, unless a written order to perform such work shall have been given by the engineer; or unless the work be subsequently certified by him, and the certificate produced at the time of demanding the payment of the monthly estimate next after such work shall have been performed.

Sub-Contracts.

The contractor will be required to perform the work himself, and no sub-contracts relieving him from the responsibility of a proper performance of his contract will be permitted, unless by the written consent of the president of the company, and no moneys shall be paid to any such sub-contractor for work or materials, without sufficient authority from the principal contractor.

Time of Commencing Work.

On the acceptance of a proposal, the chief engineer will give notice thereof to the person proposing, by letter, directed to his stated address; and in twenty days from the date of such notice, provided there be no impediment on the part of the company, or in twenty days after such impediment is removed, if there be any, the work shall be begun with an adequate force, and from that time prosecuted vigorously until its completion.

How to Progress.

It shall be understood that proper progress is not made, if the amount of work done in each month is not in due proportion to the total amount to be done up to the time fixed for completion of the contract; in which case the engineer shall call the attention of the contractor (or whoever may be in

charge of the work if the contractor be absent) to the fact, and state to him what additional exertion is necessary to be made, and what further force is required, in such reasonable time as may be prescribed.

Putting on More Force.

In default of the contractor making such additional exertion, and supplying such force, the chief engineer, or president of the company, may have such force sent to the work, and the necessary buildings may be erected to receive them at the contractor's charge and expense, who shall receive the said force in his employ, and work it at whatever price it may have been found necessary to employ it, without diminishing the previous force of the work, and regarding, always, such extra force as if employed by himself.

Causes for Detention.

There shall be no claim for detention on account of work not being laid out, unless a written notice, three days in advance, that it is required, shall have been given to the engineer; and the damage for such detention shall be estimated by the engineer. The right of way shall be furnished by the company: but if it fails to do so for any particular place, damages for detention shall not be claimed, unless the contractor be detained full twenty days after he shall have given written notice to the engineer, of his wish to commence work at such place. Then the engineer may either estimate to him the amount of damage which he shall take as satisfactory, or he may extend the time for the completion of such work by as many days beyond the contract time, as the contractor is detained beyond the twenty days following his notice to the engineer.

The Engineer.

In all cases where the word "engineer" is used, the engineer in charge of construction is meant; but the directions of any subordinate engineer shall be obeyed when given in regard to any of the ordinary operations, or where they are evidently in accord with the specifications, or when transmitting the orders of his superiors. In other cases they may be referred to the resident engineer, and finally to the chief engineer, he being the authorized officer at the time acting in that capacity.

Contractor.

The word "contractor" applies to and includes all persons contracting jointly, any one of whom shall be considered the authorized agent for and in behalf of his associates, and empowered to receipt payments of moneys, receive and act upon orders.

See page 233.

Specifications for Tunnels.*

Tunnel work will be classified as follows:

1. Tunnel excavations
2. Sinking shafts.
3. Masonry in abutments.
4. Arch-work of stone.
5. Arch-work of brick.
6. Backing.
7. Masonry in facade and approaches.
8. Masonry in shafts.

Tunnel excavation.

The tunnels to be excavated to the neat lines as shown on the drawings of the cross-sections, and to be lined, or left without lining, according to the nature of the material excavated, and as the engineer may direct.

The material excavated from the ends of the tunnels to be placed in embankment on the line of road adjacent, or wasted, as the engineer may direct. The material excavated and raised through shafts to be wasted at such convenient places near the shafts as the engineer may designate.

Tunnel excavation will be paid for by the cubic yard, counting only the material within the section, as designated by the engineer. Should the engineer deem it advisable, on account of the material passed through, to modify the section of the tunnel in order to avoid arching, all the material within the limits of such modification will be measured and paid for at the specified price per yard.

The price per yard paid for excavation to include all expense of timbering, the furnishing of all timber or other materials, the hoisting of material through the shafts, pumping of water, and all expenses of every kind connected with doing the work; also to include the cost of hauling the material, where the haul does not exceed....................feet. Should the engineer deem it advisable to transport the material to a greater distance, a price per cubic yard will be paid for the excess of haul over......................feet.

Sinking shafts.

Shafts.................. feet by..................feet in clear of timbering will be sunk at the points designated on the drawings, and will be paid for by the foot in depth. The price paid for sinking shafts to include all expenses for timbering or otherwise securing the walls.

Masonry.

Should the tunnel require lining, the general form of the masonry will be as shown on the drawing; the details of thickness of abutments and arches,

*Reference is made to Mr. Henry S. Drinker's work on "Tunneling, Explosive Compounds and Rock Drills" for other examples of tunnel specifications, and for general statistics in regard to tunnel construction, rock excavation, blasting, mason-work.

&c., to be designated by the engineer from time to time, as in his judgment may be necessary. The tunnel arch will be of stone or of brick, or partly of both, at the discretion of the engineer.

All masonry will be paid for by the perch of twenty-five cubic feet.

Masonry in abutments.

The masonry in abutments will be first-class rock range work, the stone to be accurately squared, jointed and bedded, and laid in courses of not less than twelve inches nor exceeding twenty inches in thickness, regularly decreasing from bottom to top of the wall. The stretchers shall in no case have less than sixteen inches bed for a twelve inch course, and for all courses above sixteen inches at least as much bed as face. They shall generally be at least four feet long. The headers shall have not less than twelve inches length of face; they shall hold the size in the heart of the wall that they show on the face; they shall extend entirely through the wall when its thickness is not over four feet, and shall be equal in number with the stretchers, and so arranged that a header shall come between each two stretchers. Where the thickness of the wall is more than four feet, headers shall be placed in the back of the wall at the rate of one header in the back for two in the face, and so arranged as to give a good bond. The stones for the interior of the wall must be similar in size with the face stone, of the same thickness, and bedded the same, but are not required to be jointed. They must be so arranged as to give a good bond, and be well fitted to their places; any remaining interstices to be filled with small sound stone chippings.

The whole wall will be laid in cement mortar, or the outside stones laid in cement mortar and the interior grouted, as the engineer may direct from time to time.

The face stone will generally be left with the face as they come from the quarry, the edges of the joints being pitched to a line, but no projection of over two inches outside of the neat line of the wall will be allowed.

Niches or openings will be left in the walls at convenient points to afford shelter for workmen from passing trains, and drain openings will be left in the walls to allow of water escaping, as may be designated by the engineer.

Any spaces remaining between the abutment walls and the sides of the tunnel as excavated, to be completely filled with rubble work laid dry.

Arch work of stone.

The arch stones to be laid in courses throughout, each stone being the full depth of the arch, and accurately dressed to the shapes and sizes to be designated by the engineer. They will generally be about four feet long, and so arranged as to break joint with each other. They will be set in cement mortar, with joints not to exceed one-eighth of an inch.

Arch work of brick.

The bricks used in arches to be the best quality of straight hard-burned brick; no bats, salmon or soft brick of any grade will be allowed. The brick work will be laid in cement mortar, with joints not exceeding one-eighth of an inch, and with such bond as the engineer may direct. The bricks at the time of laying to be well wet, the

cement mortar to be thin and freshly mixed, the cross-joints to be carefully mortared, each brick to be well driven to its place by blows of the mallet, and each course carefully grouted. The several courses of brick at the crown forming the key of the arch to be laid in without mortar, brick to brick, and then carefully grouted until the joints are filled. The outer surface of the arch to be well cemented to prevent leakage.

Should the engineer deem it advisable to use hoop iron to strengthen the bond of the brick work, the cost of the iron used will be allowed in addition to the price per perch for brick masonry.

Backing.

The spaces between the arch and the sides of the excavation to be completely filled, as the work progresses, with rubble work laid dry.

Masonry in facade and approaches.

The face of the arch will be formed of neatly cut ring stones, composed of alternate long and short bond stones of not less than three feet and eighteen inches respectively.

The parapet and wing walls will be built similarly to the abutments, and surmounted with a well dressed coping not less than twelve inches thick and three feet wide.

Masonry in shafts.

When the main part of the tunnel is completed, should the engineer require it, the shafts shall be walled up with a circular lining of rubble stone from the bottom to the surface of the ground, and the space between said wall and the sides of the excavation closely filled with some suitable material; otherwise the bottoms of the shafts shall be properly secured to prevent injury from any falling material.

Such culverts and drains shall be constructed as the engineer may require, any excavation necessary for this purpose shall be considered as part of the tunnel excavation, and paid for accordingly. If culverts are constructed of brick, they will be paid for at the same rate per perch as arch work of brick. Should the engineer deem it best to use tile drain pipes, or adopt any other plan for drainage, the proper cost thereof will be allowed to the contractor.

In all masonry the stone and brick must be of good, hard and durable quality, and, with the sand and all other materials used, to be subject to the inspection and approval of the Chief Engineer or his assistant.

The railroad company will furnish or pay for all lime and cement used, but the contractor shall provide a suitable place for storing lime and cement, and shall be responsible for the safe keeping of the same.

The proportions of lime, cement and sand in all mortar and grout to be as directed by the engineer. Cement to be mixed in small quantities only as used, and especial care taken to not allow it to set before being used in the work.

Any improper or condemned materials shall be removed from the work forthwith, when directed by the engineer.

The price per perch for masonry shall in every case include the furnishing of all materials (except lime and cement), the cost of scaffolding, center-

ing, &c., and all expenses attending the delivery of these materials, and all risks from floods or otherwise.

No charge shall be made by the contractor for hinderances or delay, from any cause, in the progress of the work, but it may entitle him to an extension of time allowed for completing the work, sufficient to compensate for the detention, to be determined by the Chief Engineer, provided he shall give the engineer in charge immediate notice in writing of the cause of the detention. Nor shall any claim be allowed for extra work, unless the same shall be done in pursuance of a written order from the engineer in charge, and the claim be made at the first settlement after the work was executed, unless the Chief Engineer, at his discretion, should direct the claim, or such part as he may deem just and equitable to be allowed.

SPECIFICATIONS

FOR GRADING, MASONRY, BRIDGES AND RAILS, AS USED ON THE CINCINNATI SOUTHERN R. R., BUILT UNDER THE DIRECTION OF THOS. D. LOVETT, CONSULTING AND PRINCIPAL ENGINEER.

See page 233 *a*.

Graduation.

Under this general head will be included clearing and grubbing, excavations and embankments, required for the formation of the road-bed, turnouts or depot grounds, or in any way connected with or incident to the construction or drainage of the same, or the change or crossing of roads or streams.

Clearing or Grubbing.—Grubbing will be required the entire width of the road-beds and on turnouts, depot grounds or highways, in all excavations and embankments, which are three feet or less in depth; also, in all slopes where the safety of the road requires it. The clearing shall be made on the entire length of the road, and shall not be less than one hundred feet in width on the regular road-bed, and as much more as in the opinion of the engineer will be required for the safety or convenience of the road. The ground on which the embankments or excavations are made shall be cleared of all vegetable and perishable matter. All stumps must be cut close to the surface, and none left within two feet of grade in embankments. Fences, buildings, timber and wood on the line of the road, are the property of the railway or land owner. If not removed by the owner within a reasonable time, they shall be cleared off by the contractor, piled up, and preserved for the use of the owner or railway, without charge. All refuse limbs or timber must be burned. *The contract price* for excavation and embankment must cover clearing and grubbing, as well as all the items under that head. Contractors must bear this in mind.

Excavation.—The road will be graded for a single track (except at depot grounds and turnouts.). The road-bed shall be of such width as the engineer may direct from time to time, as the work progresses—generally about twenty feet in earth cuts, and sixteen feet in rock cuts. The slopes shall be of such inclination as the engineer may designate, and in conformity to such depth of cutting and width of road-bed as may have been or may hereafter be determined and fixed upon by said engineer, as guide boundaries for the work.

Excavation will be classified under the following heads, viz.:—Earth, Hard Pan, Loose Rock, Solid Rock, Iron Ore, and Excavation in Water.

Earth.—Earth will include clay, sand, gravel, loam, decomposed rock and slate, stones and boulders containing less than one cubic foot, and all other material of an earthy kind, excepting Hard Pan as described below.

Hard Pan will consist of tough, indurated clay or other earthy material, which, in the opinion of the engineer, requires blasting for its removal; also hard tough cemented gravel.

Loose Rock.—All boulders and detached masses of rock measuring over one cubic foot in bulk, and less than one cubic yard; also all slate, coal, shale, soft friable sandstone and soapstone, and all other material except solid sandstone and limestone in place, except those described above; also stratified limestone in layers eight inches thick and under, separated by strata of clay.

Solid Rock.—All limestone and sandstone in place, in masses of more than one cubic yard; with the exception of stratified limestone described in specifications for loose rock.

The prices for excavation include all bottoming, road crossing, alteration of roads and water channels, also construction of temporary roads. Ordinary ditching alongside of embankments, from which the material is not removed more than two hundred feet, will not be paid for as excavation, but will be treated the same as borrow pits.

In road alterations or changes of water courses, if the average distance hauled exceeds the average haul of the section, the contractor will be entitled to an additional compensation of one cent per cubic yard, per hundred feet, for such excess.

On sections where the excavation exceeds the embankment, the excess shall be deposited on the side of the embankment, on the side of the second track, or at such points as the Engineer may direct; and this excess will be paid for *as excavation only.* An additional price of one cent per cubic yard will be paid on such excess for every hundred feet haul beyond an average haul of five hundred feet.

No spoil earth or other materials shall be deposited within ten feet of the slope of the excavation, but shall be placed at such a distance as in the opinion of the Engineer the safety of the road requires.

The contract price for excavation will apply to pits required for founda-

tions of masonry when water is not encountered. A price will be put in for excavation in water, which will only apply to foundation pits, and deepening the channels for running water; it must cover all classes of material, and include draining, bailing, pumping, all material and labor connected with such excavation, also the necessary dressing of the rock.

Materials found in excavations applicable to useful purposes, such as building stone, gravel, stone suitable for ballast, and minerals, shall be laid aside for use in such places as the Engineer may direct, to be applied then or subsequently, to the construction of the road under the conditions and specifications of this contract. On sections where the excavation does not exceed the embankment, and rock, gravel or mineral taken from the cuts is piled up for the use of the railway, a quantity of embankment, equivalent to the quantity of material put aside, will be allowed the contractor.

Embankments.—The embankments to be formed 15 feet wide on the top, unless otherwise directed, wlth slopes generally of 1½ horizontal to 1 vertical. Whenever the embankment is formed from ditching on either side, such ditching, and the crests of the slopes thereof, shall in no case approach within six feet, nor within double the depth of the ditch, of the foot of the proper embankment slopes, allowing always one side for a double track. No soft mud or muck shall be allowed to enter the bank. Whenever water courses or new channels for rivers require to be formed, they shall be put at such distance from the foot of the slope as the engineer may direct. Care must be taken to exclude all perishable material from embankments.

Embankments shall be built according to instruction from the Engineer, either by dumping from grade, or in layers of such thickness as he may require. Such additional height above grade shall be given to embankments as the Engineer may deem necessary to compensate for shrinkage and washing, without additional allowance. Embankments about masonry shall be built at such time and in such manner, and of such material as the Engineer may direct.

In sections where the embankment exceeds the excavation, the excess may be supplied from the sides of the adjacent cuts, on the site of the second track, so as to increase regularly the width of such cutting, or from such other places as the Engineer may direct; and no price shall be paid for increasing the width of such cuts, or for the earth borrowed for the embankment, other than the embankment price, unless the average haul exceeds five hundred feet, when there will be an extra price paid of one cent per cubic yard, per hundred feet of excess. In widening the cuts for making up deficiencies in embankments, contractors are not expected or required to excavate hard pan, loose rock, solid rock, or iron ore, unless so directed by the Engineer. In such cases, the contract price, less the embankment price, for said hard pan, loose rock, solid rock, or iron ore, will be allowed.

Macadamizing.—Where alteration of roads or turnpikes requires macadamizing, the materials used must be composed of hard durable limestone, furnished by the contractor, broken in fragments not greater than two and

one-half inches in any direction, or of the old turnpike metal, and spread with such width and depth as may be required by the Engineer. These items will be paid for by the cubic yard.

Tunnels.—Tunnels will be excavated for a single track, and will contain not less than ten cubic yards per lineal foot. The price for tunnel excavation will include all materials contained between the two portals, and within the area of its cross-section as determined by the Engineer.

If the tunnel required support, and timber is adopted, the area of its cross-section will be measured three inches outside the lagging, or if masonry is adopted, the area of its cross-section will be six inches outside the wall or arch.

The price also includes all temporary supports, such as props, scaffolding, etc. The Engineer will determine whether shafts shall be sunk, and the points for the location of the same. They shall contain not less than three cubic yards to the foot vertical. The price for the shaft excavation will include all materials contained between the surface of the ground and the soffit of the tunnel, and within the area of the shaft cross-section as determined by the Engineer. In case the shaft is sunk alongside the tunnel, it will include all material between the surface of the ground and the level of the foot of the shaft. The price must cover such curbing or other support as the sides of the shaft may require; also, whatever materials or labor required for ventilation, and keeping free of water, and will also cover hoisting and pumping machinery. All necessary wells or sumps will be paid for the same as shaft excavation.

Falls that are attributable to the carelessness of the contractor, in the Engineer's opinion, shall be removed by the contractor at his own cost; but if not thus attributable, a just and equitable allowance will be made. In case the tunnel requires permanent supporting, or the shafts lining, timber, brick or stone may be used as the Engineer may direct. Where timber is used, the Engineer will determine the kind and quality of timber, and will prescribe the general plan; this will be paid for per thousand feet board measure.

If bricks are used, they must be of the best quality of hard burnt brick, well tempered and moulded of the usual size; must be nine inches long, two and one-half inches in thickness, and four and one-half inches in width, including mortar joint after being laid. No bats, cracked or salmon bricks, under any circumstances will be allowed in the work. The brick to be laid wet in the best hydraulic cement mortar, in such proportion of cement and sand as directed by the Engineer. Grout will be substituted for mortar to such extent as directed by the Engineer. Joints to be well filled with mortar of such thickness and the bond such as the Engineer may prescribe. The exterior of the arch to be covered with a coat of hydraulic cement one-half inch in thickness. Suitable openings shall be left for the escape of water as directed by the Engineer.

Where stone is adopted, it will be constructed of First or Second Class masonry, as directed by the Engineer.

Vacancies behind the walls or above the arch will be filled with concrete or dry packing, as the Engineer may direct.

The price per cubic yard of brick work or masonry will include the furnishing of all materials, scaffolding, centering, and all other expenses necessary to the construction and completion of the masonry or brick work.

The price bid for shaft excavation is intended to pay for excavating, raising, and placing the material in spoil banks; provided the haul from the top of the shaft does not exceed five hundred feet; beyond that distance one cent per yard per hundred feet will be paid for such extra haul.

The material moved in the slope over the portals of the tunnels shall be classified and paid for the same as the material in the approaches. The work must be carried on night and day, if so directed by the Engineer.

Masonry.

First-class Masonry.—Courses of stone in abutments, piers and walls are to be not less than ten, nor more than thirty inches thick, decreasing from the bottom to the top of the walls. Stretchers to be not less than two and a half feet, nor more than six feet long; and not less than one and a half feet wide, nor less in width than one and a fourth times the depth. Headers must not be less than three and a half feet, nor more than four and a half feet long, where the thickness of the wall will admit of the same, and not less than one and a half feet wide, nor less in width than they are in depth of course. The *joints* well broken in no case less than twelve inches. Every stone must be laid on its natural bed; all the stone for the abutments, piers, and tail walls will have their beds well dressed, parallel and true to the proper line; the beds to be made always as large as the stone will admit of. Vertical joints of the face to be not less than eight inches in from the face, and as much more as the stone will work. No joint to be laid more than one-half inch in thickness; every second or third stone in each course must be a header properly arranged, and constituting one-fourth to one-third of the dressed stone in the wall. The whole of the masonry must be laid flush in good cement mortar. The backing shall be of good-sized, well-shaped stones, so as to break joints and thoroughly bond the work in all directions and have no spaces between them over six inches wide, and all spaces filled with small stones and spalls laid in cement. No hammering will be allowed after the course is set. If any inequalities occur, they must be carefully pointed off. The face of the masonry will be rock-work with drafts on the corners, and no projection of more than four inches from the proper lines (two inches in tunnels). The bridges, seats and tops of piers, abutments and tail walls are to be finished with a coping course of not less than ten inches in thickness, well bedded and jointed on longitudinal as well as lateral joints, and dressed to true surfaces on top, to project six inches or as the Engineer may direct. The foundation course must be of large flat stone. When iron bridges or iron viaducts are adopted, the pedestal stones must be of such size, shape and quality as directed by the Engineer.

Second-class Masonry- Will be of broken range rubble masonry of superior quality, with no stone less than eight inches in thickness, unless otherwise directed by the engineer, to be well bonded and levelled as well as may be without hammer dressing; to be laid dry or flush in soft cement mortar, as directed by the Engineer, to have horizontal beds and vertical joints on the face. At least one-fourth of the stones in the face to be headers evenly distributed through the wall. No joint over three-quarters of an inch in thickness. The rear of the wall shall have good beds, joints and bonds, as well as stone of good quality and size. All the quoins to have hammer dressed beds and joints and drafted corners. The top of the wall to be coped with selected stone approved by the Engineer. The coping upon which the superstructure rests shall be dressed to a level bearing.

First-class Arch Masonry—Shall be built in accordance with the specifications for first-class masonry, with the exception of arch sheeting and ring stones. The rings shall be dressed to such shape as the Engineer shall determine. The ring stone and sheeting of the arch to be of stone not less than ten inches thick on the intrados of the arch. To be dressed with three-eighths of an inch joints and to be of full depth specified for thickness of arch; the joints to be at right angles to the surface of the intrados, the face of sheeting stones to be dressed to make a close joint centering. The ring stone and sheeting shall break joints not less than one foot. The wings to be neatly stepped with selected stone the full width of wing, and not less than ten inches thick; no stone covered by the next one above less than one foot six inches; or to be finished with a neatly capped newel at end of wing. The parapets to be finished with a coping course of full width of parapet with a projection of six inches. Stone to be not less than ten inches thick.

Second-class Arch Masonry.—To be the same as second-class masonry, with the exception af the arch sheeting, for which proper stone shall be selected that shall have a good bearing throughout, and be well bonded and be of full depth of arch. No stone less than four inches in thickness on the intrados of the arch. Ring stones of all arches over eight feet span shall be dressed the same as specifications for first-class arch masonry.

Dry Box Culvert Masonry.—Will be laid with good square-shaped stone of a size and quality approved by the Engineer, and in a manner satisfactory to him. For four feet from the ends the stone to be laid in good cement mortar.

Culvert Masonry laid in Mortar.—Box Culvert masonry laid in mortar shall be of good selected building stone of good quality, and laid flush in good cement mortar to the satisfaction of the Engineer. The covering stone for all box culverts to be not less than ten inches in thickness, and to rest on the walls not less than fifteen inches.

Drain Pipe.—In localities where but a small quantity of water passes, drain pipe will be substituted for culverts. Contractors will bid for furnishing and laying Akron vitrified stone pipe, or pipes of other manufacture

that will stand equal pressure. Sizes of twelve, fifteen and eighteen inches will be used.

Retaining Walls—Will be classed as second-class masonry laid dry.

Slope Walls—Will be of sufficient thickness and slope as directed by the Engineer. The stones must reach entirely through the wall, not less than four inches thick, and twelve inches long; joints close and free from spalls. The foundation must be prepared as directed by the Engineer.

Rip Rap—Or protection stone, shall consist of large (15 to 25 cubic feet) or small stone for the protection of masonry or earth work, as directed by the Engineer.

Stone Paving—Will be made by setting stone on edge, from eight to fifteen inches in depth, as directed by the Engineer.

Cement mortar in all classes of masonry must be made of one measure of good hydraulic cement and two measures of clean, sharp sand (unless otherwise directed by the Engineer), well mixed together with water, in clean mortar beds, constructed of boards, and used immediately after being mixed.

All classes of masonry laid in cement, must be neatly pointed with cement mortar finely tempered.

All stone for the different classes of masonry must be furnished from the best quarries in the vicinity, or such quarries as the Engineer may select. Seventy-five cents per cubic yard will be paid for every mile hauled after the first mile, and a proportional rate for every fraction of a mile. All stone transportation by water over one mile in distance, will be considered equivalent to one mile of haul by wagons.

Brick masonry will be substituted for stone, at the option of the Engineer.

No masonry of any kind will be covered up before being accepted by the Engineer.

All masonry will be built according to the plans and instructions furnished by the Engineer, and will be estimated and paid for by the cubic yard, computing the actual solidity thereof. No constructive or conventional measurement will be allowed, any rule or custom in the section of the country through which the road passes to the contrary notwithstanding.

Foundations.

The contractor will be obliged to excavate for foundations of masonry to such depth as required by the Engineer. In case of rock foundations the rock must be excavated to such depth as required, and must be made level by dressing to receive the foundation course.

Paved Foundations.—Box culverts and small bridge abutments will have a paved foundation, if so directed by the Engineer; setting stones on edge, breaking joints, and extending across the entire width of the foundation.

Timber Foundations—Will be such as the Engineer may prescribe, and be paid for per thousand feet board measure, the price to cover furnishing material, framing, and putting in place. Necessary iron work shall be paid

for per pound after being worked. The price paid shall cover the cost of putting it in proper place.

Piles—Will be paid for per lineal foot, and shall not be less than ten inches in diameter at the small end, and shall be straight and sound. If required, shall be shod with wrought iron, which shall be paid for the same as other iron work in foundations. Piles must have the bark taken off, and must be driven until they move not more than one-half inch to the blow of a hammer weighing not less than 2,000 pounds, with 30 feet fall. Only the actual number of feet of piles, timber, and plank, used and left for use in foundations will be paid for. The best quality of white oak, or other timber equally good for the purpose, acceptable to the Engineer, shall be used in all foundations if accessible; if not, such timber as can be procured in the locality, and in all cases it must be acceptable to the Engineer.

Coffer-Dams.—Where coffer-dams are required for foundations, the prices bid for timber, piles, and iron, on the section will be allowed for said coffer-dams, and must cover all risks from high water and otherwise, draining, pumping, bailing, and all materials connected with the coffer-dams. Sheet piling will be classified as timber in foundations, and paid for per thousand feet board measure. Contractors bidding for masonry must also put in a price for foundations for the same.

Bridges and Viaducts.

Timber trestles, girder, and road bridges will be paid for per thousand feet board measure, computing the actual length of the stick of timber required and left for use, and iron in the same per pound. The prices must cover all materials and labor requisite to completely finish the structure.

For information in regard to bridges either in iron or wood, also iron trestles, see Specifications for Bridge and Iron Viaducts.

General Conditions Applicable to all Work.

All materials used in the construction of the road will be subject to the inspection and acceptance of the Engineer, who will submit them to such tests as he may desire.

Commodious passing places, for public and private roads, shall be made and kept in good condition by the contractor, and he shall provide and maintain good and sufficient fences, for keeping up enclosures and the preservation of crops. The contractor will be held responsible for trespass or damage to the adjacent properties or the public, for any acts or omissions on the part of himself or his employes.

Any parties under the direction of the engineer shall be permitted to pass or haul any material required for the road over any section, such persons not interfering with the work of the contractor. Right of way and necessary lands for borrow pits, spoil banks, channels, ditches, roads, etc., will be provided by the trustees, as early as practicable, but they are not to be held responsible for any delay caused by legal proceedings beyond their control.

Contractors must carefully preserve bench marks and stakes; in case of neglect they will be charged accordingly. Falls and slips, if not occasioned by the negligence of the contractor, are to be paid for the same as the regular classification, except in tunnel excavation.

The contractors shall take all risks from floods and casualties of every description, and shall make no charge for detention from such causes, but shall be entitled to a reasonable extension of the time for the completion of the work.

The quantities marked on the profile are an approximation, and will not govern the final estimate.

Disorderly and quarrelsome persons must be discharged by the contractor, if in the opinion of the engineer the good of the road requires it.

Contractors will not themselves, nor by their agents, give nor sell any ardent spirit to their workmen, or any person at or near the line of the railway; or allow any to be brought on the works by the laborers or any other persons, and will do all in their power to discountenance their use in the vicinity of the work by persons in their employ; and they will not allow any person in their employ to commit trespass on the premises of persons in the vicinity of the works, and will forthwith at the request of the trustees or engineer, discharge from their employ any that may be guilty of committing damage in this respect.

Contractors must satisfy themselves of the nature of the soil; of the general forms of the surface of the ground; of the quantity of materials required for forming the embankments or other work, and all matters which can in any way influence their contract; and no information upon any such matters derived from the maps, plans, profiles, drawings or specifications, or from the engineer or his assistants, will in any way relieve the contractor from all risks or from fulfilling all the terms of this contract.

The contractors will remove, at their own expense, any materials disapproved by the trustees or the engineer, and will remove and re-execute any works, without extra charge, and within such time as fixed by the engineer, appearing to the trustees or the engineer, during the progress or within twelve months after completion, to be unsoundly or improperly executed, notwithstanding any certificate as to the due execution of the same. On their default, such work will be done by the trustees at the contractor's expense.

The contractor will give personal attention to the work.

The engineer shall have power to direct the application of force to any portion of the work which in his judgment requires it. And to order the increase or diminution of force at any point he may indicate.

The contractor having the contract for graduation, before commencing his work, and immediately after signing the contract, shall open and maintain a good and safe road, for passage on horseback, along the whole length of his work, and on portions of the road where there are no highways convenient for the wagoning of supplies, he must open and maintain such

roads, without charge therefor, and in his proposal must take this into consideration.

The word "Engineer" shall mean the consulting or principal engineer, unless otherwise expressed.

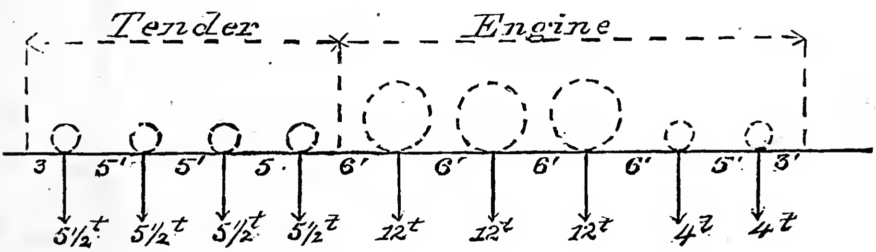
SPECIFICATIONS FOR BRIDGES AND TRESTLE-WORK.

Bridges will be constructed either in *iron*, *wood*, or a *combination* of both.

Contractors will furnish a general plan with detailed drawings and diagrams of strains, for all bridges and iron trestles, otherwise their tenders will not be considered.

Through bridges must not be less than fourteen feet in width in the clear, and eighteen feet six inches in height in the clear, measuring from the top of the rail.

Rolling Load.—All parts of the bridges and trestles must be proportioned to sustain the passage of the following rolling load, at a speed of not less than thirty miles per hour, viz: two locomotives coupled, each weighing thirty-six tons on drivers, in a space of twelve feet; total weight of each engine and tender, loaded, sixty-six tons in a space of fifty feet, and followed by loaded cars weighing twenty tons each in a space of twenty-two feet. Weight of each locomotive and tender to be distributed according to the following diagram. An addition of from ten to thirty per cent. will be made



to the strains produced by the rolling load (considered as static) in the calculation of floor beams, stringers, suspension links, counter-rods, and all other parts which are liable to be thrown under strain by the passage of a rapidly moving load. Bridges must not deflect under the passage of such a train, more than one twelve-hundredth of their length, and shall return to their original camber. Trestle posts and vertical lateral rods and struts must be of sufficient strength to resist, in addition to the live and dead load, a pressure of wind equal to thirteen pounds per square foot, when the trestle is covered with passenger cars. In bridges vertical lateral rods and struts must be of sufficient strength to resist, in addition to the live and dead

loads, a pressure of wind equal to fifty pounds per square foot, unless otherwise specified.

Dimensions of Parts.—The iron work shall be so proportioned that the weight of the structure including the floor, with one hundred and twenty-five pounds per lineal yard added for rails, spikes and joints, together with the above specified rolling load, shall in no part cause a tensile strain of more than ten thousand pounds, per square inch of sectional area, nor a shearing strain of more than seven thousand five hundred pounds to the square inch. The strain in compression will be reduced with the ratio of diameter to length of post, according to the Gordon formula, with a factor of safety of one sixth. Columns for testing shall be furnished by the contractor. Experiments will be made under the direction of the engineer, to determine the limit of elasticity, and also the ultimate strength of the metal to be applied in the formula. In all members subject to transverse strains, the maximum compression must not be more than eight thousand pounds per square inch.

Shearing strain on pins must not be more than 7,500 pounds per square inch. The strain on semi-intrados of eyes not more than 10,000 pounds per square inch, or the compressive area not less than the section of the bar. The eye must not be less in strength than the body of the bar.

Quality of Iron. Iron used under tensile strain, shall be tough, ductile, of uniform quality, and capable of sustaining sixty thousand pounds per square inch of sectional area without fracture, and twenty-five thousand pounds per square inch of area, with a smart blow from a hammer while under strain, without taking a permanent set. The reduction of area at breaking point shall average twenty-five per cent.; elongation fifteen per cent.; when cold it must bend without sign of fracture from ninety to one hundred and eighty degrees.

Iron used under compressive strain must be tough, highly fibrous, of uniform quality, and capable of sustaining twenty-five thousand pounds per square inch of area without taking a permanent set.

The engineer will have the privilege at any time to select any of the bars manufactured for the bridge, cut from the same specimen bars one and one-half inches in diameter and twelve inches long, and submit them to the foregoing tests. Should the bars thus tested fail to stand the tests, this will be considered sufficient evidence that the iron used does not comply with the requirements of the specifications.

All bars subject to tensile strain shall be tested by the contractor, under the direction of the engineer, to twenty thousand pounds per square inch of sectional area, with a smart blow from a hammer while under strain without permanent set. While under the test strains, should any bar extend or contract more or less than it should do according to co-efficients of extension and contraction previously determined from experimental tests of sample bars of the grade of iron to be used, all such bars shall be rejected, for this or any other imperfection. A variation of $\frac{1}{1000}$ of an inch per foot each

way for a strain of twenty thousand pounds per square inch of area will be allowed. Bars subject to shearing strain shall be of the best quality of iron, and subject to such tests as the engineer may desire.

Every bid must be accompanied by six specimen bars, one and one-half inches in diameter, and twelve inches long, stamped with the name of the bidder, and to be of the quality of iron that is intended to be used. All iron used must be equal in strength and all other qualities to the specimen bars.

Castings must be made of good tough cast iron; metal not less than three-quarters of an inch in thickness and be subject to the following test: A bar of iron five feet long, one inch square, four feet six inches between supports shall bear a weight of five hundred and fifty pounds suspended at the center. The engineer may at any time require such specimen bars to be cast from the same metal as that used in the structure. No castings will be permitted except in the minor details.

Workmanship.—All workmanship must be first class. All abutting joints must be planed or turned. One-sixty-fourth of an inch will be the maximum error allowed in eye bars, and not more than one-hundredth of the diameter of the pin or hole.

In riveted work in joints shall be square and truly dressed. Rivet holes shall be spaced accurately and directly opposite each other. Rivets must be of the best quality of iron and must completely fill the holes. The area of rivets shall not be less than the sectional area of the joined pieces.

Ends of bars having threads upon them must be enlarged beyond the diameter of the bar, enough to make the bar full size at the bottom of the thread.

Washers and nuts must have a uniform bearing.

All iron must be painted on all surfaces before leaving the manufactory, with two coats of metalic paint and oil, and with a third coat of lead and oil after the structure is erected.

Timber.

The timber shall be of white or yellow pine, or other kind of timber approved by the Engineer, free from wind shakes, large knots, decayed wood, sap or any defect that will impair its strength or durability. No sap angle will be allowed. All timber must be inspected by the Engineer and none used without his approval. All framing must be done in a thorough and workmanlike manner.

Ties must be of the best quality of white oak, not less than thirteen feet in length. Must be placed one foot from centre to centre, and every alternate tie must be fastened to the stringer at both ends.

Guard Timbers, six inches by eight inches, must be placed about one foot outside the rails, must be closely notched one inch on each tie and bolted to the ties every four feet.

Angle Irons, three inches by three inches by three-eighths of an inch, must be spiked to the guard timber every eighteen inches alternately on the top and side. The spike holes must be counter-sunk to receive the heads of the spikes.

Wooden Bridges.

Angle-blocks, tubes, splicing keys, washers, parting blocks, brace-shoes, and bridge seats are to be made of cast iron.

High hexagonal nuts are to be used; when used on truss rod, the nuts are to be dressed *on both ends* perpendicular to the line of the rods.

Iron Trestle Work

Will be built in spans of twenty feet or upwards in length; supported by trestles in vertical sections of thirty feet and fractions of thirty feet, as each particular case may require.

Trestle posts must be at least ten feet from centre to centre at the top.

The trestle work will be measured and paid for as follows, viz.:—

The entire length of trestle work, measured on centre line of structure, from centre to centre of end pins at so much per lineal foot; trestles per vertical foot, measuring from the top of the masonry to the bottom of the stringers.

Materials in trestles must be proportioned to support the corresponding spans.

General Conditions Applicable to Bridges and Trestles.

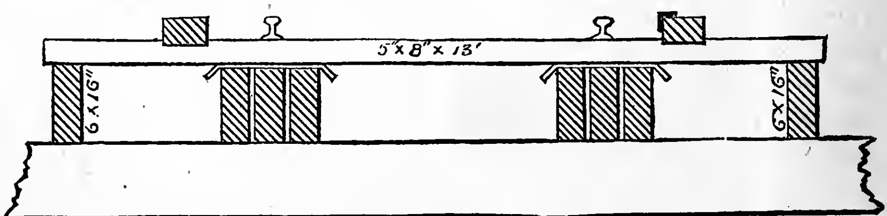
Contractors must furnish and put in place wall-plates, stringers, cross-ties, guard rails and angle irons, over piers and abutments of all structures, so as to connect the roadway of the structure with the ballasted track. No extra allowance will be made for the same.

The contractor shall take all risks from floods and casualties of every description, and must furnish all materials and labor incidental to or in any way connected with the manufacture and erection of the structure.

Measurement.—Iron and combination bridges are to be measured from centre to centre of end pins.

Wooden bridges are to be measured from out to out of end posts, whether the bridge be of one or more spans.

The following diagram shows the section of floor on all structures where wood stringers are used, and where the opening between floor beams is thirteen feet. When the opening is increased or diminished the stringers will be proportioned accordingly. The track stringers must be securely bolted to the floor beams, and covered with No. 15 galvanized iron thirty inches in width for the entire length.



Scale ¼" to 1'

All bridges or trestle work must be completed ready for the rails.

The contractor will not be obliged to raise the iron bridges or trestles in the mountains until transportation can be had by rail.

River Navigation.

Where rivers are navigable they must at all times during the construction and erection of the bridge be kept free for navigation.

All coffer-dams and other obstructions must be removed by the contractor, when directed by the engineer, leaving the river entirely unobstructed, except the actual space occupied by the masonry.

Tests.

Before the final estimate is paid, a thorough test of the structure will be made by the engineer, by loading each span with such rolling load, at such rate of speed, as described under the head of rolling load, and also by causing the load to remain on each span for the space of one hour or more. And each span must return to its original camber when the load is removed.*

The word "engineer" shall mean the Consulting or Principal Engineer, unless otherwise expressed.

Specifications for Sixty-Pound Iron Rails.

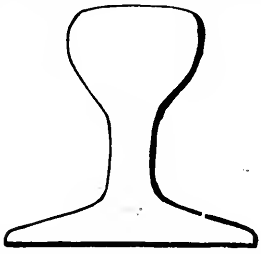
General Clause.—The weight of the rail is to be sixty pounds per lineal yard of rail. The rail must be in every respect according to tracing and template, and of uniform section throughout the whole length. The maximum allowance to be admitted in the sectional dimensions must not exceed $\frac{1}{48}$ of an inch.

Pile and mode of Manufacture.—The piles for the rail must be composed in weight of thirty-five per cent. of the best crystalline hammered iron for the head; thirty per cent. of good sound puddled bars, rolled from hammered blooms, for the stem: and thirty-five per cent. of the best fibrous iron for the bottom flange. The top and bottom slabs are to be of the same length and width as the pile; the other slabs must all lay flat, breaking joint laterally and of the same length as the pile.

No short pieces will be allowed in the pile. The pile must be heated in the furnace with the part corresponding to the top of the rail, up; it must first be hammered under a five-ton hammer, or compressed in rolls at a slow motion to secure a thorough welding of all parts; reheated and then rolled.

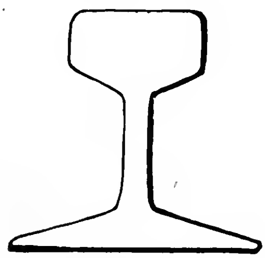
* The new bridge of the Cincinnati Southern Railroad Company over the Ohio at Cincinnati was tested on Thursday, November 8th, 1877, with satisfactory results. The bridge spans the river at a point nearly a mile below the suspension bridge, and is nearly half a mile in length. It is the seventh bridge built over the Ohio, and the third at this point. It was built by the Keystone Bridge Company, of Pittsburg, for about $750,000, and is regarded as one of the cheapest pieces of work in bridge building in the West. The test consisted in running trains of increasing weight over each span in succession, with such stops and sudden jerks as were needed to prove thoroughly the strength of the structure. First, a single engine was sent across, then two engines, then three, and so on up to seven; then four cars, loaded with fifteen tons of rails each, were added, making the total weight upon a single span 3880 tons. Under this immense pressure the total deflection of the channel span, which is 520 feet in length, was less than two inches.—*Philadelphia Public Ledger.*

Cutting of Ends.—The ends must be cut square with the axis of the rails, and must show a smooth surface, clean, compact, and without defect.



PATTERN OF IRON RAIL

Cincinnati Southern Rail Road



PATTERN OF STEEL RAIL SCALE 1/4

Straightening.—The rails must be straightened on the four sides while hot. The straightening is not to be made by percussion, but by screws or cams. Reheating any part of the rail will not be allowed. The surface of the rail must be smooth and without any defects, such as cracks, blisters, welding seams, etc. No patching of defects will be allowed.

Drilling and Punching.—The rails must be punched or drilled at the ends in accordance with the tracing, the allowance tolerated in the dimensions of the holes or notches and the distance between them must not exceed one thirty-second of an inch. The holes must be cylindrical, and punched or drilled so as not to show any projection beyond the uniform surface of the rail.

Length.—The rails must be thirty feet in length each. Ten per cent. of their numbers will be allowed of shorter length down to twenty-four feet, but they must all be of an even number of feet, and must not vary therefrom more than one-eighth of an inch.

Weight.—An allowance of two per cent. each way for individual rails, and of one per cent. each way for the whole quantity of rails received, will be made in weight. If too light, the rail will be rejected; if too heavy, it will be accepted at the nominal weight with the two per cent. allowance added.

Marking.—Each rail must be marked about two feet from the ends with the maker's mark and the year and month in which it was rolled; the letters and figures must be distinct and not less than one inch in height.

Every approved rail must be marked with the Inspecting Engineer's private stamp, otherwise it will not be accepted.

Inspecting and Testing.—The rails will be inspected by an engineer in lots of one thousand bars. Five rails out of a lot will be selected by the inspector and submitted to the following tests:—

Each of the selected rails must carry seven and one-half tons in the center between bearings, four feet apart in the clear, for five minutes, with a deflection not exceeding one-quarter of an inch, and must come back to its original line when the weight is removed, within $\frac{1}{100}$ of an inch.

In the same position, the rails must carry fifteen tons in the center between bearings for five minutes without breaking. The rail will then be

broken in two and each half submitted to one blow of a hammer weighing 600 pounds, and falling six feet vertically. The bearings for the rails must be four feet apart in the clear, and made of cast iron, fastened on oak frames supported by stone pillars with solid foundations at least three feet below the surface. The section of the broken rail must show a clean and compact metal throughout, free from cinders, welding seams, or other imperfections denoting impurity or imperfect welding. The head of the rail must show on top at least three-quarters of an inch of small grain, hard iron; the bottom flange of the rail must show all fibrous iron; and the remainder of the section a gradual mixture of grain and fibre.

Should one of the rails fail under any of the foregoing tests, five more will be selected out of the same lot and similarly tested; if more than ten rails have failed, the whole lot of one thousand bars to which they belong will be rejected. The Inspecting Engineer will have free entry to the works, and full power to inspect the manufacture at any time, to satisfy himself that the rails are being made in accordance with the stipulations of this agreement; any remark which he may have to make will be addressed to the manager of the works, and not to the workmen.

Certificate.—A certificate will be delivered by the Inspecting Engineer for each lot of rails approved and stamped. No part of the work will be done by any other manufacturer without the express consent of the trustees.

Guarantee.—The rails will be guaranteed for three years after laid in track. The value of all rails which within that period of time will show material signs of imperfections or weakness will be refunded to the trustees at the rate of $25 per ton, the rails remaining the property of the trustees. This clause will not apply to rails laid within one thousand feet of stations or in yards.

Ohio River Bridge Specifications.

Foundations.

South Abutment.—The south abutment will rest on a pile foundation. The top of the platform must be at least six feet below the present surface. It must be of one layer of white oak timber, twelve by twelve inches, laid with close joints and fastened to the caps by drift bolts.

Caps must be of one stick of white oak, twelve by twelve inches, and fastened to the piles by drift bolts.

Piles must be of the best quality of white oak; they must not be less than twelve inches in diameter at the small end, and must be straight and sound; the bark must be taken off; they must be driven to the rock, and, if required, shall be shod with wrought iron. Any pile injured by driving must be withdrawn and replaced with another. The platform must be thoroughly grouted before the first course is laid. After the piles are

capped the material must be excavated to a depth of two feet below the top of the caps, the excavation extending two feet outside the platform, on all sides; and the spaces under, above and around the platform, not occupied by the masonry, must be filled with concrete one foot above the top of the platform. The remaining space must be filled with the material excavated.

Piers.

Pier No. 1.—Pier No. 1 will rest on a pile foundation. The same specifications will apply to this as for the south abutment.

Pier No. 2 (*Pivot Pier*).—This pier will rest on a limestone stratum two feet and eight inches in thickness, as shown in the elevation drawings. The top of the rock must be made level by dressing the same to receive the foundation course, and the space between the excavation and the masonry must be filled with rock to the level of the bed of the river.

Pier No. 3.—This pier will rest on the six feet eight inch stratum of limestone, as shown in the elevation drawing. The top of the ledge must be excavated one foot to receive the foundation course. The space between the rock and masonry must be filled with concrete. The balance of the space between the excavation and the masonry must be filled with broken rock.

Pier No. 4.—This pier will rest on the same stratum of rock as Pier No. 3. The specifications applying to foundation of Pier No. 3 will also apply to this foundation.

Pier No. 5 —This pier will rest on the same stratum as Piers Nos. 3 and 4. The specifications applying to foundations of Piers Nos. 3 and 4 will also apply to this foundation, with the exception of excavating one foot in the rock, in lieu of which the top of the ledge must be made level by dressing the rock.

Pier No. 6.—This pier will rest on the six feet stratum of limestone, as shown in elevation drawings. The top of the rock must be leveled by dressing the same, and foundation pit filled up to the present surface with the material excavated.

In all the foregoing described foundations the pits must be kept dry while the masonry is being laid.

Masonry.

The stone for the masonry must be of the best quality of limestone. The courses must not be less than eighteen inches nor more than thirty inches thick, decreasing uniformly from the bottom to the top of the walls. Stretchers to be not less than two and one-half feet nor more than six feet long, nor less in width than one and a fourth times the depth.

Headers must not be less than three and a half feet nor more than six feet long, and not less in width than they are in depth of course. The joints must be well broken, and in no case less than sixteen inches. Courses of stone will be continuous around and through the walls. Every stone must be laid on its natural bed, and have both beds well dressed, parallel

and true to the proper line. The beds to be made always as large as the stone will admit of.

Vertical joints of the face to be not less than twelve inches in from the face, and as much more as the stone will work. Particular care must be taken to have them well filled with mortar. No joints to be laid more than five-eighths nor less than three-eighths of an inch in thickness.

Every second or third stone in each course must be a header; headers must be properly arranged, and constitute one-fourth to one-third of the dressed stone in the wall. The whole of the masonry must be laid flush in good cement mortar, made of one measure of good hydraulic cement and two measures of clear, sharp sand, well mixed together with water, and used immediately after being mixed.

The backing shall be of good sized well shaped stones of the same thickness as the face stones, with their beds well dressed parallel and true to the proper line, and arranged so as to break joints, thoroughly bonding the work in all directions, having no spaces between them over six inches wide. All the spaces must be filled with small stones and spalls laid in cement.

One course must be impervious to water before the next is laid. No hammering will be allowed after the course is set. The face of the masonry will be rock work, with drafts on the corners, and with no projection more than three inches from the proper line, except the cut work shown in the detail drawings, which is to be bush-hammered.

The bridge seats, tops of piers, abutments, and tail walls, are to be finished in accordance with the detail drawings.

The coping stones must be of the size and shape shown in the drawings. Must be well bedded and closely joined on all sides. Wrought iron clamps must also be used as shown on drawings.

All necessary drilling and dressing must be made to receive the iron work to insure a close fit.

On the Pivot Pier, iron work for the float, as shown in the drawing, must be inserted as the work progresses.

All the masonry must be neatly pointed with cement mortar finely tempered.

No masonry will be laid in freezing weather.

Concrete must be made by measure of four parts of sound broken limestone of uniform size (that will pass through a two inch ring), two parts of clean, sharp sand, and one part of good hydraulic cement, all well mixed together before being put in place, and well rammed in layers of about one foot thick.

All materials used (stone, cement and sand) will be subject to the inspection and acceptance of the Engineer, who will submit them to such tests as he may desire.

Superstructure.

The superstructure of this bridge will be of iron, with the exception of cross-ties and guard timbers.

Bidders will furnish a general plan, with detail drawings and diagrams of strains for each span, otherwise their tender will not be received.

The bridge must be not less than fourteen feet in width in the clear, and not less than eighteen feet six inches in height in the clear, measuring from the top of the rail. The road-way on each span will be constructed so as to leave on the rail only one-half of the camber of the truss.

The channel span of the bridge shall not be less in width than twenty feet from centre to centre of trusses.

The draw must be geared for both hand and steam power, so as to turn either way. All machinery for the same must be furnished and put in place by the contractor.

The hand gearing must be so arranged that two men can easily turn the draw, in a calm day, in two and one-half minutes.

Steam power must be applied of sufficient capacity to turn the draw in one minute, with a pressure of forty pounds to the square inch.

The bearing of the ends of the draw on the piers must be firm, so as to insure a smooth track for the passage of trains. All locks must be worked by gearing from the centre of the draw, and be self-adjusting when the draw is six inches out of line.

Not more than three feet and three inches shall be occupied from the base of the rail to the lowest point in the superstructure of the bridge.

[NOTE.—The requirements for Rolling load, Dimensions of Parts, Quality of Iron, Workmanship, and Timber, are the same as those previously given in these Specifications.]

River Navigation.

The river must at all times during the construction and erection of the bridge, be kept free for navigation of steamers, coal fleets, tows of all kinds, and rafts.

All coffer-dams and other obstructions must be removed by the contractor, leaving the river entirely unobstructed, except the actual space occupied by the masonry.

Risks.

The contractor shall take all risks from floods and casualties of every description, and must furnish all materials and labor incidental to or in any way connected with the construction and erection of the bridge.

Time.

The bridge hereby contracted for shall be commenced on or before the 25th March, 1875, and be completed according to the foregoing specifications in compliance with the attached contract by 31st December, 1876.

The word "Engineer" shall mean the Consulting or Principal Engineer, unless otherwise expressed.

Tests.

Before the final estimate is paid, a thorough test of the bridge will be made by the Engineer, by loading each span with such rolling load, at such

rate of speed, as described under the head of rolling load, and also by causing the load to remain on each span for an hour or more. The deflection of each span during the tests made by the engineer must not be more than the following:—

For the five hundred and twenty feet span, five inches.

For each of the three hundred feet spans, three inches.

For the one hundred and ten feet span, one and one-tenth inches.

For each span of the three hundred and seventy feet draw, one and eight-tenths inches. And each span must return to its original camber when the load is removed.

Monthly Estimates.

The Engineer will establish from the amount of the bid a scale of prices to serve as a basis for the estimation of the value of the work done each month.

Changes.

The Trustees reserve the right to change the depth of the foundations, and sizes of the piers and abutments, as described in the foregoing pages.

N. B.—For specification of Drawbridge, see Appendix A, page 285.

Freight Locomotive, "Consolidation" Pattern,

For the Lehigh Valley Railroad. 4 feet 8½ inches gauge. Fuel, Anthracite coal.

Cylinders.

Diameter	1 ft.	8	inches.
Stroke of piston	2 ft.		
Length of steam-ports	1 ft.	4	"
Width of steam-ports		1¼	"
Width of exhaust-ports		2½	"
Travel of valve		5⅜	"
Outside lap of valves		¾	"
Inside lap of valves		1/32	"
Exhaust nozzles, variable.			

Wheels.

Diameter of driving wheels	4 ft.	2⅜	inches.
Diameter of truck wheels	2 ft.	6	"
Diameters between centres of front and driving wheels	14 ft.	9	"
Total wheel base of locomotives	22 ft.	10	"
Total wheel base of locomotive and tender	46 ft.	2	"
Diameter of driving-axle journals		7	"
Length of driving-axle journals		8	"
Diameter of main crank-pin bearing		5	"
Length of main crank-pin bearing		5	"

Boiler.

Outside diameter of smallest ring of boiler	4 ft.	6	"
Thickness of boiler plates (iron)		½	"
Number of tubes	198		
Length of tubes	11 ft.		
Outside diameter of tubes		2	"
Length of fire-box inside	9 ft.	10	"
Width of fire-box inside	2 ft.	9¾	"
Depth of fire-box inside (sloping)	44½—55		"
Thickness of fire-box plates (steel), side and back		5/16	"
Thickness of flue-sheet		½	"
Thickness of crown-sheet		⅜	"
Square feet of grate surface	27.6		
Square feet of heating surface in fire-box	149		
Square feet of heating surface in tubes	1132		
Total square feet of heating surface	1281		

Weight.

Weight of engine in working order	100,000	pounds.
Weight of engine on driving wheels	88,000	"

Remarks.

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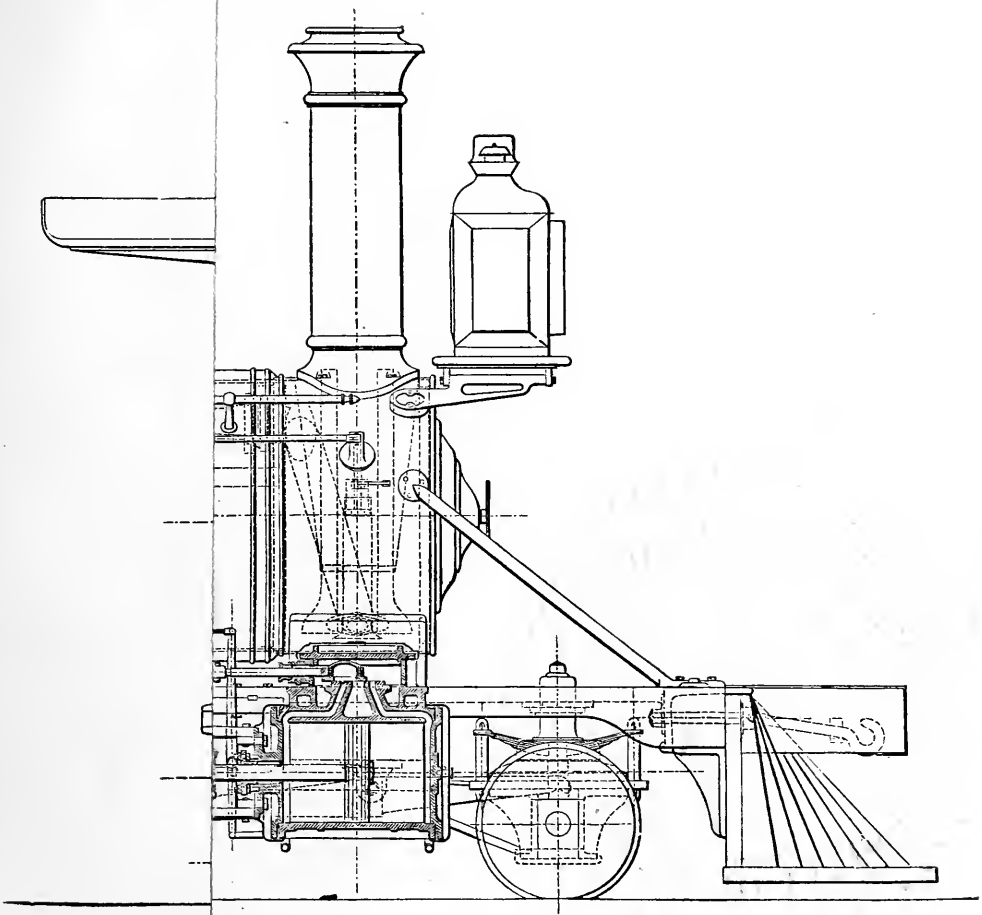
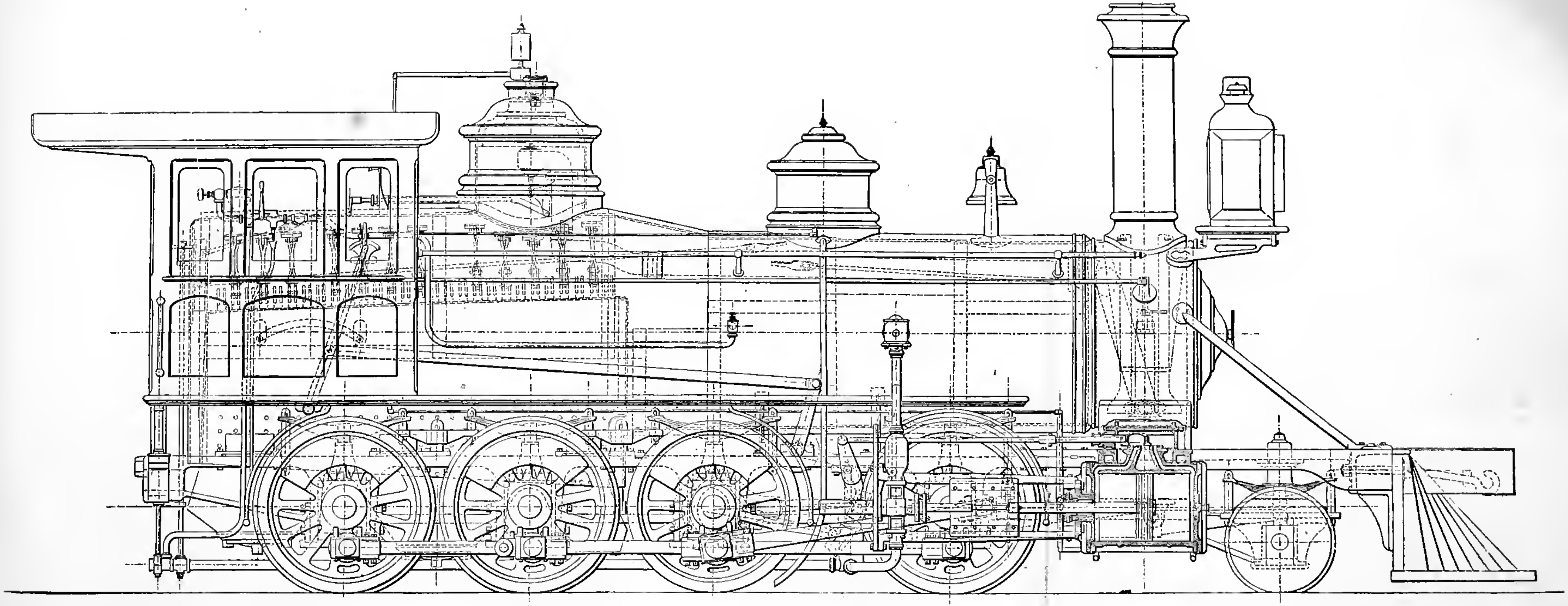


tons.*

* For specifications of engines, with dimension details in full, see *Manual for Railroad Engineers*, by George L. Vose, C. E., Professor of Civil Engineering in Bowdoin College.



CONSOLIDATION PATTERN.

FREIGHT LOCOMOTIVE. "CONSO

Weight of engine in working order . .
Weight of engine on driving wheels . .

Remarks.

Locomotives of this class have been used on the Lehigh Valley Railroad since 1866, in which year the locomotive "Consolidation," from which the class has taken its name, was built by the Baldwin Locomotive Works in accordance with the plan and specifications furnished by Mr. Alexander Mitchell, then Master Mechanic of the Lehigh and Mahanoy Railroad.

On this division of the Lehigh Valley Railroad, over maximum grades of one hundred and twenty-six feet per mile, the maximum load is thirty-five loaded four-wheeled coal cars (three hundred and twenty-nine gross tons of cars and lading), and the usual load twenty-five loaded four wheeled coal cars (two hundred and thirty-five gross tons of cars and lading). On the same division, over a grade of seventy-six feet per mile, one of these engines draws a maximum train of one hundred and forty empty four-wheeled cars (four hundred and seventy-six gross tons), at a speed of eight miles per hour. Its usual train is one hundred empty cars (three hundred and forty gross tons). Compared with the "Ten-Wheeled" pattern of locomotive, cylinders eighteen by twenty-four, driving wheels four and four and a half feet diameter, weight on driving wheels about sixty-thousand pounds, the performance is as shown in the following table:—

	Grade 126 feet per Mile. Gross Tons of Train.	Grade 76 feet per Mile. Gross Tons of Train.
Maximum Load of "Consolidation" Locomotive,	329	476
" " of "Ten-Wheeled" "	235	340
Usual " of "Consolidation" "	235	340
" " of "Ten-Wheeled" "	169 to 200	221

Consumption of fuel—"Consolidation" Engine, 3¾ tons daily.
" " "Ten-Wheeled" " 3¼ "

The ordinary repairs for a series of years have been one mill per mile run greater for the "Consolidation" than for the "Ten-Wheeled" engine.

On the Wyoming Division of the same railroad, from Sugar Notch to Fairview, the grade is one in fifty five (ninety-six feet per mile) for twelve miles in length, combined with curves of eight and ten degrees radius. The curves are frequent, and there are but two tangents, each less than one mile long, in the whole twelve miles. Up this incline engines of this class can take forty loaded four-wheeled coal cars. The usual train is thirty-five such cars, which are taken at a speed of twelve miles per hour. The cars weigh, each, three gross tons, eight hundredweight, and carry, each, six gross tons of coal. The weight of train, therefore, which a "Consolidation" engine takes up the grade combined with curves, as stated, is from three hundred and twenty-nine to three hundred and seventy-six gross tons.*

* For specifications of engines, with dimension details in full, see *Manual for Railroad Engineers*, by George L. Vose, C. E., Professor of Civil Engineering in Bowdoin College.

Freight Locomotive, "Mogul" Pattern,

For the Dom Pedro Segundo Railway of Brazil. Gauge, 5 feet 3 inches. Fuel, Bituminous Coal.

Cylinders.

Diameter	1 ft.	6	inches.
Stroke of piston	2 ft.		
Length of steam-ports	1 ft.	4	"
Width of steam-ports		1¼	"
Width of exhaust-ports		2½	"
Travel of valve		5⅜	"
Outside lap of valves		¾	"
Inside lap of valves		$\frac{1}{32}$	"
Exhaust nozzles—double, variable.			

Wheels.

Diameter of driving wheels	4 ft.	6	inches.
Diameter of truck wheels	2 ft.	6	"
Distance between centres of front and rear driving wheels	15 ft.		
Total wheel-base of locomotive	22 ft.	8	"
Total wheel-base of locomotive and tender	44 ft.	3	"
Diameter of driving-axle journals		7	"
Length of driving-axle journals		8	"
Diameter of main crank-pin bearing		4½	"
Length of main crank-pin bearing		4½	"

Boiler.

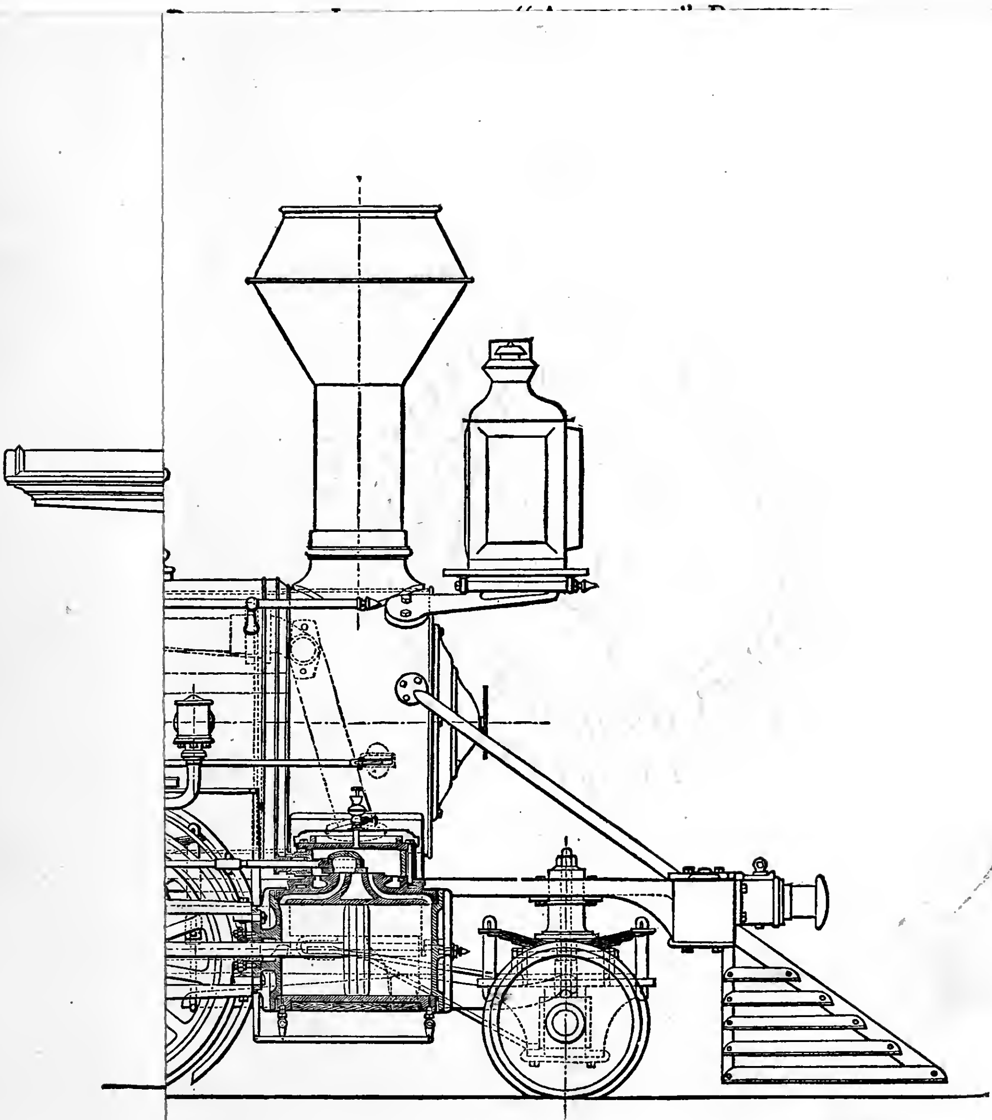
Outside diameter of smallest ring of boiler	4 ft.	3	inches.
Thickness of boiler plates (iron)		½	"
Number of tubes	159		
Length of tubes	11 ft.	2¾	"
Outside diameter of tubes		2	"
Length of fire-box inside	5 ft.	5	"
Width of fire-box inside	2 ft.	11½	"
Depth of fire-box inside	5 ft.	3½	"
Thickness of fire-box plates (copper) side, back, and front sheets		½	"
Thickness of flue-sheet		⅞	"
Thickness of crown-sheet (steel)		⅜	"
Square feet of grate surface	16		
Square feet of heating surface in fire-box	103		
Square feet of heating surface in tubes	937		
Total square feet of heating surface	1040		

Tender.

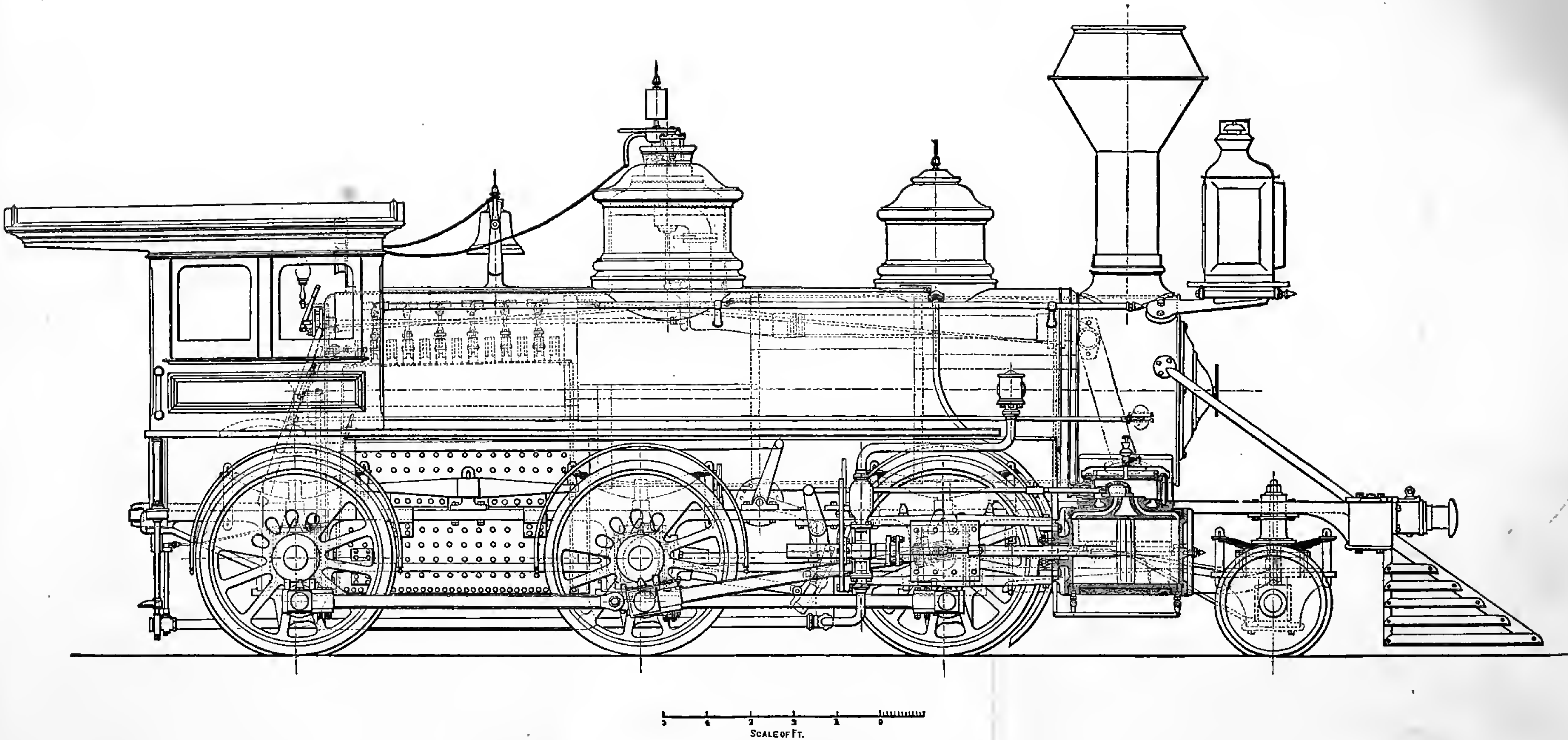
Number of wheels	8		
Diameter of wheel	2 ft.	4	inches.
Diameter of tender-axle journals		3⅜	"
Length of tender-axle journals		7	"
Capacity of tank	2000 gallons.		

Weight.

Weight of engine in working order	80,000	pounds.
Weight of engine on driving wheels	68,000	"
Weight of tender, empty	20,000	"

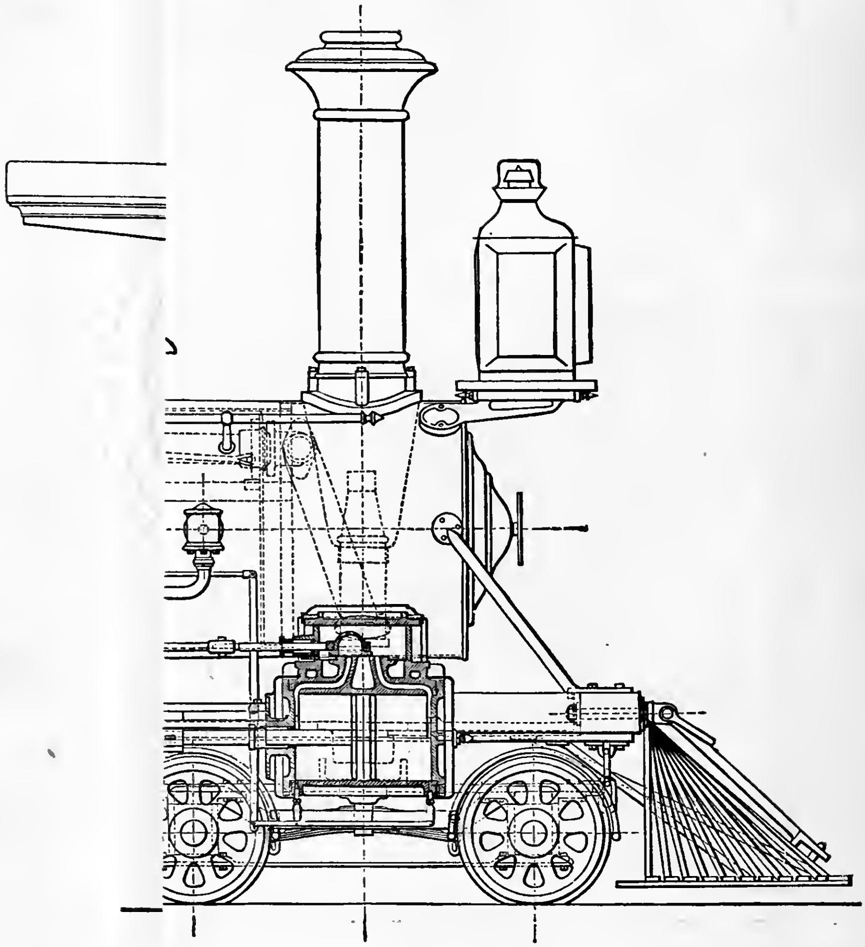


Weight of engine in working order . . .	71,300 pounds.
Weight of engine on driving wheels . . .	45,800 "
Weight of tender empty	22,000 "



MOGUL PATTERN.

Freight Locomotive "Mc



RN.

Weight of engine in working order .
Weight of engine on driving wheels .
Weight of tender, empty . . .

Passenger Locomotive "American" Pattern.

For the Pennsylvania Railroad Company. Constructed in accordance with drawings furnished by the Company. (Pennsylvania Railroad Company's "Class C.") Gauge 4 feet 9 inches. Fuel, Bituminous Coal.

Cylinders.

Diameter	1 ft.	5	inches.
Stroke of piston	2 ft.		
Length of steam-ports	1 ft.	4	"
Width of steam-ports		1¼	"
Width of exhaust-ports		2½	"
Travel of valve		5	"
Outside lap of valves		¾	"
Inside lap of valves		none.	
Exhaust-nozzles—double.			

Wheels.

Diameter of driving-wheels	5 ft.	2	inches.
Diameter of truck-wheels	2 ft.	4	"
Distance between centres of front and rear driving wheels	8 ft.	6	"
Total wheel-base of locomotive	22 ft.	5⅝	"
Total wheel-base of locomotive and tender	44 ft.	3⅛	"
Diameter of driving-axle journals		7	"
Length of driving-axle journals		7½	"
Diameter of main crank-pin bearing		3¾	"
Length of main crank-pin bearing		3¾	"

Boiler.

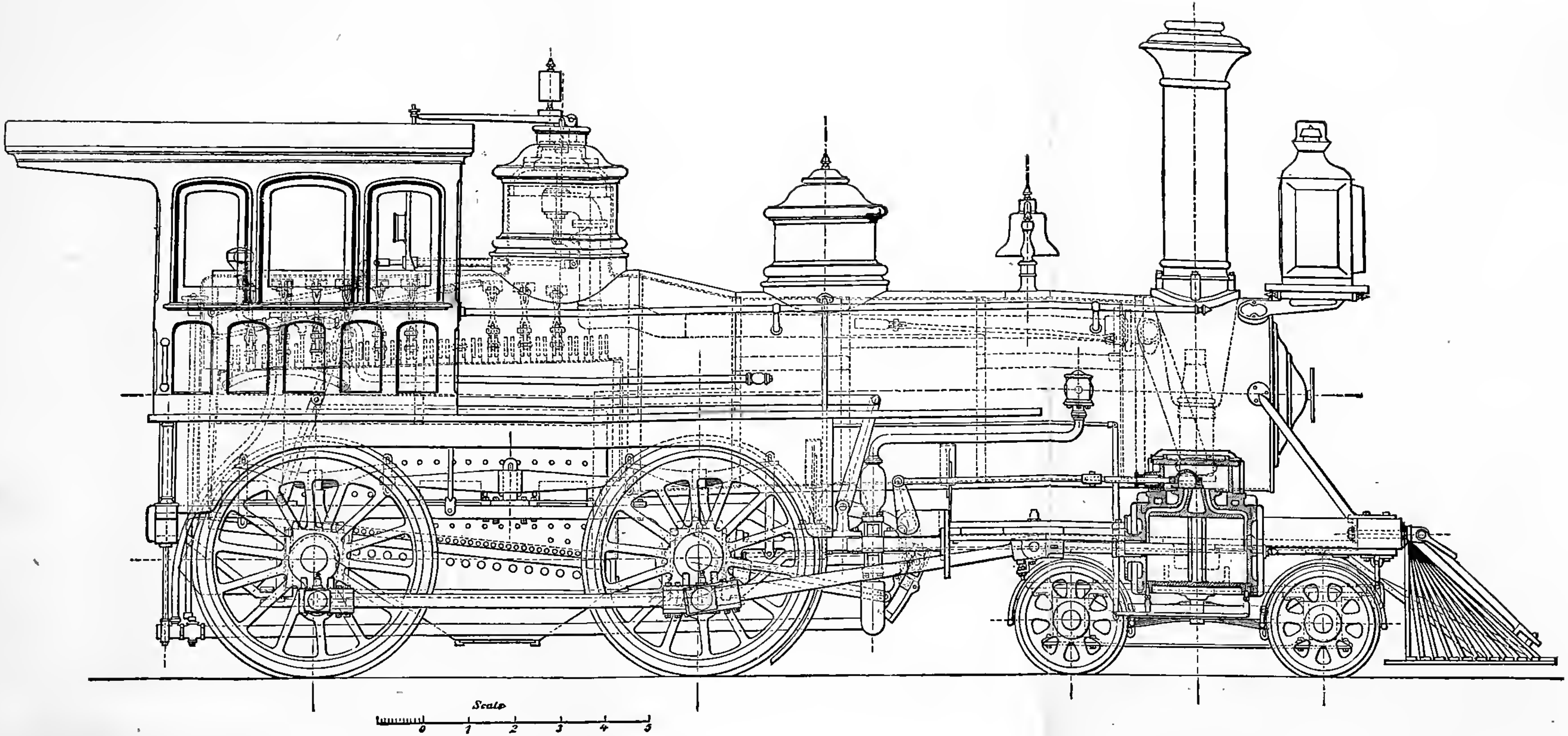
Outside diameter of smallest ring of boiler	4 ft.	1⅜	inches.
Thickness of boiler-plates (steel)		5/16	"
Nnmber of tubes	155		
Length of tubes	10 ft.	8	"
Outside diameter of tubes		2¼	"
Length of fire-box inside	6 ft.	⅝	"
Width of fire-box inside	2 ft.	10⅞	"
Depth of fire-box inside	5 ft.	7	"
Thickness of flue-sheet		½	"
Thickness of sides, back, and crown-sheet		5/16	"
Square feet of grate surface	18		
Square feet of heating surface in fire-box	106		
Square feet of heating surface in tubes	971		
Total square feet of heating surface	1077		

Tender.

Number of wheels	8		
Diameter of wheels	2 ft.	9	inches.
Diameter of tender-axle journals		3¼	"
Length of tender-axle journals		7	"
Capacity of Tank	2400 gallons.		

Weight.

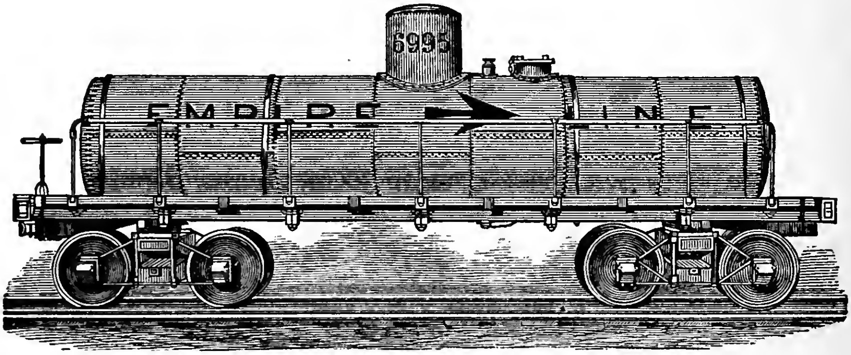
Weight of engine in working order	71,300	pounds.
Weight of engine on driving wheels	45,800	"
Weight of tender empty	22,000	"



PASSENGER LOCOMOTIVE—AMERICAN PATTERN.

SPECIFICATION "C"

FOR BOILER TANK CARS, 100 BARRELS CAPACITY, EMPIRE TRANSPORTATION COMPANY, ADOPTED DECEMBER, 1876.



1st. In these specifications reference is to be had to any accompanying drawings, and also to the sample car when furnished. These specifications to be followed when they differ from the drawings or car, and they and the drawings to be followed when they differ from car. Builders in all cases do, by contracting to build, agree to indemnify and save harmless the Empire Transportation Company from all patent right claims. The make and character of wheels, axles and springs to be determined by the Empire Transportation Company, and the said Company reserve the right to require changes from these specifications, drawings, and sample car.

Boiler.

2d. Capacity of boiler not to be less than one hundred, nor more than one hundred and one barrels of forty-five gallons each. No variation from this size will be permitted. The gallon referred to contains two hundred and thirty-one cubic inches.

3d. The material composing boiler to be as follows: The shell and dome (except as hereinafter specified) to be made of a good quality of No. 7 wrought-iron boiler plate, weighing not less than seven and one-half pounds to the square foot. The heads of boiler, of like plate, five-sixteenth inches thick, weighing twelve and one-half pounds to the square foot; and such iron as requires flanging must be charcoal boiler-plate. All of the boiler iron composing the shell and dome must be guaranteed by the builders to be capable of resisting a tensile strain of not less than 50,000 pounds to the square inch. In these specifications, the Birmingham Wire Gauge is adopted as the standard for indicating the thickness of all plate irons.

4th. The boiler to be cylindrical in form, same as sample car. The shell to be composed of seven rings, each ring to be formed by two plates of

proper dimension to make the average inside diameter of cylinder sixty-six and one-half inches, and the length of boiler sides two hundred and ninety-three inches. The heads of boiler to be convex, each head forming the segment of a sphere, the versed sine of each segment to be seven inches, making the length through the axis of cylinder three hundred and seven inches. The form over which the flanges of heads are turned or formed must have a radius of not less than two inches. The under side plate, forming in part the first ring at either end of boiler must be of No. 1 boiler-plate iron, having a thickness of five-sixteenth inches. The under side plate forming in part the five intermediate rings of boiler, must be of No. 3 boiler-plate iron, having a thickness of one-quarter inch.

5th. Each boiler head to be strengthened by a thrust plate, this plate to be of the same quality of iron as the heads (No. 1 boiler plate); said plate to extend horizontally across either head at a point twelve inches up from lowest point of head; that portion of the plate coming in contact with the side of shell to be flanged, overlapping sides and extending back sufficient to be taken in by the rivets securing head, &c. All joints to be thoroughly caulked; and all joints that cannot be caulked without, must be filled with copper gaskets. Every description of joint must be perfectly oil tight.

6th. The dome to be forty inches in diameter, and twenty-four inches in height from top of boiler to top of dome side. Top of dome to be convex, raised in centre four and one-half inches. Dome to be secured to boiler on the centre of the centre ring. The centre ring of boiler should have a length between vertical seams equal to the diameter of base of dome, including flanges. Boiler to have two three-quarter inch holes at lowest points inside of dome marked a a on drawing, and a hole through shell immediately under centre of dome of sixteen inches diameter.

7th. The space between centre of rivets must not exceed one and one-half inches. All vertical and horizontal seams in boiler, except those around manhole, valve chamber, base of dome and the seams in dome, must be double riveted with a lap of three and one-quarter inches. Size, quantity and location of rivets are as follows:

Location of Rivets.

LOCATION.	NUMBER.	SIZE. DIAM. IN.		SIZE. LENGTH. IN.
Rivets securing horizontal joints, . . .	716	½	x	⅞
" " vertical " . . .	2176	½	x	⅞
" " dome to boiler, . . .	92	½	x	⅞
" " " head, ...	80	½	x	1
" " vertical joint in dome, . .	20	½	x	⅞
" " valve chamber, . . .	21	½	x	2
" " manhole base, . . .	30	½	x	2

[NOTE.—Variations from the above sizes must be made at points where two or more sheets of unequal thickness come in contact. For example,

where $\frac{3}{16}$ and ¼ inch iron is joined ½ x 1 inch rivets must be used. When ¼ and $\frac{5}{16}$ in. iron is joined ½ x 1⅛ in. rivets must be used. Rivets securing thrust plate, boiler head and sides must be ½ x 1½ inches. All rivets to be iron of best quality.]

8th. Each boiler to be provided with one manhole and cover, located and secured in the centre of dome head, constructed and arranged substantially as the Sample. Each boiler also to be fitted with one discharge-valve, of the pattern and manufacture which may be prescribed by the Empire Transportation Company, located at the lowest point on the under side of shell immediately under the dome. The valve stem to extend upward through the dome to a point near top of manhole, through which valve is to be operated. The top end of valve stem is held in position by a wrought-iron bracket secured to under side of dome head, as seen in sample and drawing.

9th. Discharge valves to be fitted with oil-tight caps, secured to frame of car by movable collar and chain. The various kinds of caps, keys, manholes and discharge valves to be uniform in size and construction, and each variety to be interchangeable with its class.

10th. No tank will be considered as accepted from builders until it has been thoroughly inspected and its capacity and tightness satisfactorily demonstrated by water test, and by at least two trips of actual service.

11th. Plan of constructing boiler tank car frame is fully and clearly shown in the drawings and sample car. The gas pipe tubes marked No. 4, used instead of wooden side-sills, must have an outside diameter of three inches, and an inside diameter of two and one-half inches. Extra strong timbers to be of the best quality of white oak, and all iron work not herein otherwise described, to conform in size and quality to that of sample car; except wheels, axles, bearing and draw springs, which shall be as may be specially provided. Wheels to be accurately fitted on axles to gauge furnished by the Empire Transportation Company.

12th. Trucks for one hundred barrel tank cars, to be uniform in style and construction with Empire Line standard trucks, except in the wheels, axles and bearing springs. Bearing springs must have a freight carrying capacity of not less than fifteen tons. Wheels to be of a like strength and weight as those used under the "Pullman parlor cars." Size of axle as follows:

Length finished, ...	6 feet	11 inches.
" of journal, ...		7 "
" of collar, ...		0⅝ "
" from back journal shoulder to wheel seat, .		2 "
" of wheel seat, ...		6½ "
Diameter of axle at hub, . . .		4⅞ "
" " " middle, ...		4 "
" " " wheel seat, . . .		4¾ "
" of back journal shoulder, . .		4$\frac{7}{16}$ "
" of journal, ...		3½ "
" of collar, ...		4⅜ "
" of concave shoulder back of wheel seat,		5 "

Axles will be turned up with a concave shoulder back of wheel seat. Any thickness of iron over the diameter indicated must be turned off with a gradual taper toward centre. Wheels to be forced on axle with a pressure of not less than twenty-five tons.

13th. Flooring of boiler cars to be wrought iron No. 14 wire gauge. The iron to be neatly fitted around the boiler, leaving a space between floor and boiler of one inch. The floor to be secured to wooden stringers A by ½ x 2 inch lag screws to the tubes No. 4 by hooked bolts, and to the brackets by rivets. At no point must the iron floor be permitted to come in contact with the boiler.

14th. Cars to have a hand railing on either side made of three-quarter-inch gas pipe, supported by iron post secured to outer ends of brackets. Length of hand railing to be twenty-four feet eight and one-half inches. Height from the floor thirty-two inches.

15th. Boiler to be neatly fitted at ends between the timbers marked F on drawing. These timbers to be worked into shape conforming to that of boiler heads. The interstices between boiler heads and timbers must be substantially caulked with oakum, so that there can be no possible longitudinal motion of the boiler. To further secure the boiler from lateral movement, the straps x 1 will have knuckle joints formed in their longitudinal centres. On top of and to boiler on a line with the straps, wrought-iron lugs will be secured. Through these the knuckle joint bolt will pass; thereby firmly holding and preventing lateral twisting of boiler on car frame.

16th. Cars to have brakes on each truck, connected with an equalizing lever, as shown on drawing and sample car. Oil boxes must be provided with patent spring lids, manufactured by Kinzer & Jones, of Pittsburg, Pa. Journal bearings to be of phosphor bronze and brake shoes malleable iron All bolts and nuts to be filled in accordance with the Cumming's lock nut patent.

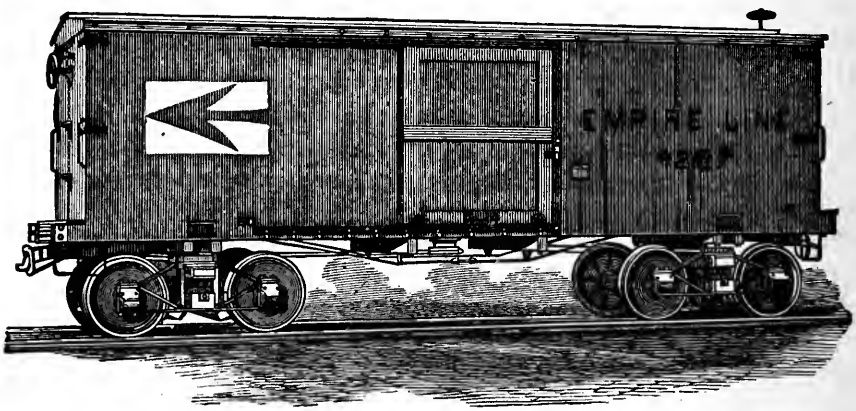
Painting.

17th. All the iron work, except boiler and dome to be painted black; the wood work to have two coats of Brandon yellow, ground and mixed in pure linseed oil; boiler and dome to have three coats of paint over every part of their surface. The first coat coming in contact with the iron must be brown metallic paint. The other two coats must be pure white lead or zinc. Each car to have two cast-iron card cases, and two sets of cast-iron figures, denoting car No. They and the card cases to be secured to outside of sills, and painted white, emblems, lettering and figures to be as per sample car, unless otherwise specified. Before painting, boiler and dome must be cleaned on its external surface from rust, scales, grease and all dirt.*

*All the Empire Transportation Co's specifications are followed by bills of materials, giving dimensions and positions of the parts in the cars. These are omitted here as being beyond the scope of this work.

SPECIFICATIONS

FOR BOX CARS, EMPIRE TRANSPORTATION COMPANY, ADOPTED JULY, 1872. REVISED JULY, 1873, REVISED JULY, 1875.



First.—In these specifications reference is to be had to any accompanying drawings, and also to the Sample Car when furnished. These specifications to be followed when they differ from drawings or car, and they and the drawings to be followed when they differ from car. Builders in all cases do, by contracting to build, agree to indemnify and save harmless the Empire Transportation Company from all patent right claims.

The make and character of wheels, axles and springs to be determined by the Empire Transportation Company.

The Empire Transportation Company reserve the right to require changes from these specifications, drawings and sample car. No car will be considered as accepted until inspected and approved by the Company's Superintendent of Cars.

Second.—All material used in the construction of these cars to be of the best quality, and workmanship first-class.

All timbers must be dressed on all their sides, and conform to the sizes and character of wood hereinafter specified.

Siding boards to be of white pine, smoothed and beaded, and they and the roofing boards to be free from all loose knots, cracks and decay. That portion of the floor immediately over the body bolster must be of dry white oak.

Third.—Car covering to be A. P. Winslow's Patent Iron Roof, put on as directed by the Winslow Roofing Co., and under their immediate supervision. The iron must be galvanized, unless otherwise directed.

Dimensions of car body as follows:

Extreme length of main frame,	29 ft.	5½ in.
Length of box frame, not including siding,	27 "	10 "
Width " " " "	8 "	0 "
Height from bottom of side sill B to top of plate E,	7 "	2 "
Curve of roof,	0 "	4 "

Side sills B and centre stringers C must not be gained at bolsters or transoms.

Intermediate stringers D, are to be gained at bolster, and also transoms. Mode of gaining stringers D shown on drawing.

Fourth.—Each car to be fitted with two grain doors, same as in sample car; also with two cast iron card cases, secured to siding near car door, as shown on drawing; also with an iron threshold at each door, fitted between door posts, and secured to top of floor; also with a full set of bearing and draw-springs, and double mouth draw heads. All bolt heads and nuts, coming on inside of car, must be sunk flush with the inside surface, except those in top plates.

Fifth.—Car wheels to be broad-tread, diameter thirty-three inches, fitted on hammered axles, four and three-eighth inches in diameter by six feet nine and one-half inches long. Wheels to be correctly fitted to gauge furnished by Empire Transportation Co.

The trucks to be uniform in style and construction with trucks under sample car, unless otherwise specified. Body truss rods to be provided with turn-buckles, or their equivalent. Drawheads to be made of wrought-iron, strengthened at back end, such as that made by Berry, Courtney & Wilson, Pittsburg.

Sixth.—The following directions are to be strictly observed in turning up each car axle: all inside angles are to be turned concave; the shoulder back of wheel seat must be turned entirely off with a gradual taper.

Finished size of axle as follows:

Extreme length,	6 ft. 9½ in.		
Button on end of axle,	4⅛ in.	diam.	⅝ in. long.
Journal,	3¼ "	"	5⅜ " "
Space between wheel seat and journal	4⅛ "	"	2 " "
Wheel seat,	4$\frac{3}{16}$ "	"	2 " "

Seventh.—Number of car to be stamped with three-fourths inch figures on ends of body-bolster, and also on ends of truck bolsters.

Eighth.—All joints, tenons, and mortices to be coated with a solution composed of lime and sulphate of copper, to prevent decay.

Ninth.—End sills A to be painted over their external surface. Ends of side sills B, and stringers C and D to be coated with paint, about one foot back from end sills, before box-frame has been erected. The under sides of side sills B to be thoroughly coated with paint their entire length, after siding has been put on.

Car to be painted with yellow oxide. Emblem, vermillion red on white field, of size and position shown on drawing. Eight inch white letters and

figures on side of car, unfinished block, and six inch figures on ends, same style and color.

Tenth.—Cars to have brakes on each truck, connected with equalizing lever, as shown on drawing and sample car.

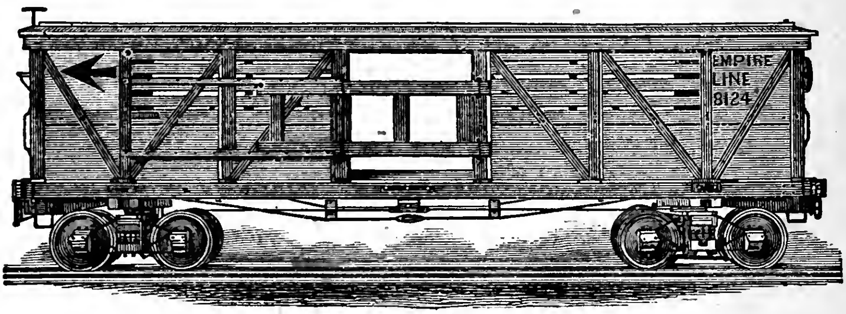
Eleventh.—Cars to have the patent Oil Box Lid manufactured by Kinzer & Jones, of Pittsburg, Pa.

Twelfth.—Cars to have Phospher Bronze Bearings and Malleable Iron Brake Shoes.

Thirteenth.—All Bolts and Nuts to be fitted in accordance with the Cumming Lock Nut Patent.

Specifications

For Rack Cars, Empire Transportation Company, Adopted July, 1872. Revised July, 1873, Revised July, 1875.



First.—In these specifications reference is to be had to any accompanying drawings, and also to the sample car when furnished. These specifications to be followed when they differ from drawings or car, and they and the drawings to be followed when they differ from car. Builders in all cases do, by contracting to build, agree to indemnify and save harmless the Empire Transportation Company from all patent right claims.

The make and character of wheels, axles and springs to be determined by the Empire Transportation Co.

The Empire Transportation Company reserves the right to require changes from these specifications, drawings and sample car. No car will be considered as accepted until inspected and approved by the Company's Superintendent of Cars.

Second.—All material used in the construction of these cars to be of the best quality, and workmanship first-class.

All timbers must be dressed on all their sides, and conform to the sizes and character of wood hereinafter specified.

Slatting boards to be of white oak, smoothed, and they and the roofing boards to be free from all loose knots, cracks and decay. That portion of the floor immediately over the body bolster must be of dry white oak. Slatting from floor to belt rail to be closed tight. Above belt rail to be spaced with five inch slatting, and space between slatting three inches. Belt rail V to be secured to each post and braces by two rivets, made of ⅜ inch iron, at corners. Where belt rails intersect, they are to be secured by the combined angle and lug bolt.

Third.—Car covering to be of white pine boards, one inch thick, matched, planed and painted.

Dimensions of car body as follows:

Extreme length of main frame	36 ft.	6 in.
Length of rack frame, from out to out of corner posts	35 "	2 "
Width " " " " "	8 "	11 "
Height from bottom of side sill B to top of plate E	7 "	4 "
Curve of roof	0 "	4 "

Side sills B and centre stringers C must not be gained at bolsters or transoms.

Intermediate stringers D are to be gained at bolster, and also transoms. Mode of gaining stringers D shown on drawing.

Fourth.—Each car to be fitted with two cast iron card cases, secured to siding on either side near car door, as shown on drawing; also with a full set of bearing and draw-springs, and double mouth draw-heads. All bolt-heads and nuts, coming on the inside of car, must be sunk flush with the inside surface, except those in top plates.

Fifth.—Car wheels to be broad-tread, diameter thirty-three inches, fitted on hammered axles, four and three-eighths inches in diameter by six feet nine and one-half inches long. Wheels to be correctly fitted to gauge furnished by Empire Transportation Co.

The trucks to be uniform in style and construction with trucks under sample car, unless otherwise specified. Body truss rods to be provided with turn-buckles, or their equivalent. Drawheads to be made of wrought-iron, strengthened at back end, such as that made by Wilson & Leggett, Pittsburg.

Sixth.—The following directions are to be strictly observed in turning up each car axle: all inside angles are to be turned concave; the shoulder back of wheel seat must be turned entirely off with a gradual taper.

Finished size of axle as follows:

Extreme length	6 ft. 9½ in.	
Button on end of axle	4⅛ in. diam.	⅝ in. long.
Journal	3¼ " "	5⅜ " "
Space between wheel seat and journal	4⅛ " "	2 " "
Wheel seat	$4\frac{3}{16}$ " "	0 " "

Seventh.—Number of car to be stamped with three-fourths inch figures on ends of body-bolster, and also on ends of truck bolsters.

Eighth.—All joints, tenons and mortices to be coated with a solution composed of lime and sulphate of copper, to prevent decay.

Ninth.—End sills A to be painted over their entire external surface. Ends of side sills B, and stringers C and D to be coated with paint, about one foot back from end sills, before rack-frame has been erected. The under sides of side sills B to be thoroughly coated with paint their entire length.

Car to be painted with yellow oxide. Emblem, vermillion red on white field, of size and position shown on drawing. Eight inch white letters and figures on side of car, unfinished block, and six inch figures on ends, same style and color.

Tenth.—Cars to have brakes on each truck, connected with equalizing lever, as shown on drawing and sample car.

Eleventh.—Cars to have the patent Oil Box Lid manufactured by Kinzer & Jones, of Pittsburg, Pa.

Twelfth.—Cars to have Phospher Bronze Bearings, and Malleable Iron Brake Shoes.

Specifications

For Stock Cars, Empire Transportation Company, Adopted July, 1873. Revised July, 1875.

First.—In these specifications reference is to be had to any accompanying drawings, and also to the sample car when furnished. These specifications to be followed when they differ from drawings or car, and they and the drawings to be followed when they differ from car. Builders in all cases do, by contracting to build, agree to indemnify and save harmless the Empire Transportation Company from all patent right claims.

The make and character of wheels, axles and springs to be determined by the Empire Transportation Company.

The Empire Transportation Company reserves the right to require changes from these specifications, drawings and sample car. No car will be considered as accepted until inspected and approved by the Company's Superintendent of Cars.

Second.—All material used in the construction of these cars to be of the best quality, and workmanship first-class.

All timbers must be dressed on all their sides, and conform to the sizes and wood hereinafter specified.

Slatting boards to be of white oak, smoothed, and the roofing boards to be free from all loose knots, cracks and decay. That portion of the floor immediately over the body bolster must be of dry white oak. Slatting from floor eighteen inches up to be closed tight to within three inches of belt rail,

then to be spaced with five-inch slatting, and space between slatting to be three inches. Belt rail V to be secured to each post and braces by two rivets, made of ⅜-inch iron. At corners where belt rails intersect, they are to be secured by the combined angle and lug bolt No. 23.

Third.—Car covering to be of white pine boards, one inch thick, matched, planed and painted.

Dimensions of car body as follows.—

Extreme length of main frame	29 ft.	5½ in.
Length of rack frame, from out to out of corner posts	28 "	1 "
Width " " " "	8 "	11 "
Height from bottom of side sill B to top of plate E	7 "	4 "
Curve of Roof	0 "	4 "

Side sills B and centre stringers C must not be gained at bolsters or transoms.

Fourth.- Each car to be fitted with two cast-iron card cases, secured to siding on either side near car door as shown on drawing; also with a full set of bearing and draw springs, and double mouth draw-heads. All bolt heads and nuts coming on the inside of the car must be sunk flush with the inside surface, except those in top plates.

Fifth.—Car wheels to be broad-tread, diameter thirty-three inches, fitted on hammered axles, four and three-eighths inches in diameter, by six feet nine and one-half inches long. Wheels to be correctly fitted to gauge furnished by the Empire Transportation Company.

The Trucks to be uniform in style and construction with trucks under sample car, unless otherwise specified. Body truss rods to be provided with turn-buckles or their equivalent. Draw-heads to be made of wrought iron, strengthened at back end, such as that made by Wilson, Leggate & Co., Pittsburg, Pa.

Sixth.—The following directions are to be strictly observed in turning up each car axle:—All inside angles are to be turned concave: the shoulder back of wheel seat must be turned entirely off with a gradual taper.

Finished size of axle as follows:

Extreme length	6 ft. 9½ in.	
Button on end of axle	4⅛ in. diam.	⅝ in. long.
Journal	3¼ "	5⅜ "
Space between wheel seat and journal	4⅛ "	2 "
Wheel seat	$4\frac{3}{16}$ "	

Seventh.—Number of car to be stamped with three-fourths inch figures on ends of body bolster, and also on ends of truck bolsters.

Eighth.—All joints, tenons and mortices to be coated with a solution composed of lime and sulphate of copper, to prevent decay.

Ninth.—End sills A to be painted over their entire external surfaces. Ends of side sills B, and stringers C and D to be coated with paint, about one foot back from end sills, before rack frame has been erected. The under sides of side sills B to be thoroughly coated with paint their entire length.

Car to be painted with yellow oxide. Emblem, vermillion red on white field, of size and position shown on drawing. Eight inch white letters and figures on side of car, unfinished block, and six inch figures on ends, same style and color.

Tenth.—Each car to be provided with two hatch holes in roof, located on either side of roof, four feet eight inches from ends of car. Dimension of hatch covers 19×22 inches.

Eleventh.—Car to have double brakes operated from either end. One brake wheel to be operated from top of car, and one from the end.

Twelfth.—Cars to have patent oil box lid manufactured by Kinzer & Jones, of Pittsburg, Pa.

Thirteenth.—Cars to have phospher bronze bearings, and malleable iron brake shoes.

SPECIFICATIONS

FOR BUTTER AND EGG CARS, EMPIRE TRANSPORTATION COMPANY, ADOPTED NOVEMBER, 1876.

1st. In these specifications reference must be had to any accompanying drawings, and also to the sample car when furnished. These specifications to be followed when they differ from the drawings or car, and they and the drawings differ from the sample car. The specifications of the Empire Line standard box cars adopted, will be the specifications for the butter and egg cars, except in the following particulars.

Lining.

2d. The car to be lined above the belt rail including sides, ends and roof of seven-eighth inch or three-quarter inch white pine boards, dressed and matched. Lining must be dry and of a fair quality, free from loose knots, cracks and other objectionable features. Before the lining has been nailed in place, thick air-tight paper must be introduced between it and the posts and braces. The paper to be so joined and fitted as to be as near air-tight as possible. This paper must be introduced back of all the lining, at ends, sides and roof, below as well as above belt rail.

Inside Doors and Wickets.

3d. Each car to have double inside doors on either side of car. The inside doors to be constructed of two inch thickness of one inch white pine boards, dressed and matched, with the lining paper introduced between them. Each door to be in four sections of equal dimensions, each section to be hinged to the door posts by two twelve inch strap hinges, and opening inward. One of the lower sections in either door to be so hinged that they

can when desired be lifted off. In one of the upper sections in either door, there must be a wicket, twenty-three inches wide by twenty-seven inches high, hinged at the top and opening outward and upward, and held open when desired by an iron arm pivoted to wicket, the loose end being held in position by a cast-iron rack secured to the door. The wicket when closed will be secured by a gravity button. The several sections of the doors when closed will be secured by staples and gravity hooks. The wickets to be made in the same manner as the door.

Icing Doors, Ventilators, &c.

4th. Each car to have two icing doors, one at each end of car. The doors to be arranged to open by sliding to the left. Ventilators like the sample furnished, will be fitted in the icing doors. Registers will be attached to the inside of doors immediately over the air-vent. These registers will be made of galvanized iron, about No. 20, and so arranged as to be readily and easily operated by the hand through the partially opened door. The doors will be constructed with a rim surrounding the entire door, and projecting inward sufficient distance from the inside plane of door to protect the register from coming in contact with the siding when the door is moved back and forth. The sliding arrangement of the icing doors will be similar to the large side doors; the top guide will be supported by a suitably formed wooden rail, and secured by lag screws; the bottom guide will be supported by cast-iron brackets, and also secured by lag screws. The doors when closed will be secured by a hasp, staple and pin, or by some other suitable means that may be hereafter decided.

Ice Box.

5th. Each butter and egg car to have two iron ice boxes, one fitted in either end of car. The boxes to be made of No. 11 common plate iron. The size of box to be as follows: Length seven feet five inches; height, three feet four and one-half inches; width, two feet two inches. The form of box to be as shown in the drawing and sample car. The top to be circular, having a radius of seven inches. The front to be parallel with the end of car. The back to be parallel with the front, from the bottom up to a height of sixteen inches, from which point the back is inclined forward sufficient to meet the curved top. The lower angles of the front and back will be formed with a radius of four inches. The angles at ends may be either circular or square, as the builder may decide to flange the ends or introduce angle iron in uniting the corners. The boxes must be caulked and made water-tight, from and including the bottom up to a height on a line with the bottom of icing doors. In the front of box there must be an opening conforming in size and position of end icing doors, hereinafter given.

Waste Pipe and Register.

6th. Each ice box to have a waste pipe, of which the conducting tube is to be gas pipe, having an inside diameter of two inches. The pipe to be attached to box and extend down and through the car floor about three

inches below its under side. The position of pipe is shown in drawing and sample car. Ice boxes must each have a register in their back, located immediately inside and back of the ventilator in icing doors. The register will be arranged so as to be operated from the inside of car. The area of the opening in the register must not be less than area of the opening in the ventilator. There must not be any openings between the ice box and the end of car around the icing door. Should the box not fit up tight at all points around the door by reason of the curved top, any opening that may thus occur must be suitably closed up, so that no air can pass into the car except through the register in back of box.

Securing Ice Box.

7th. The ice boxes are to be secured in place as follows : At a height of thirty-three inches from floor, wooden cleats five by seven inches will be bolted to posts and braces, the cleats extending across the car end and along the sides a distance equal to the width of box. The box resting on these cleats is further secured by seven anchor bolts, secured to box either by rivets or bolts. The thread end of bolts pass out through end of car to which the boxes must be substantially and securely held. Four of the anchor bolts secure the bottom of box and three the top. The edges of the iron box around the icing doors will be secured by wood screws.

Sweating Drip.

8th. Each icing box must have attached thereto a sweating drip made of No. 24 galvanized iron. The drip to extend over the entire under side of box bottom, and up the sides and ends a sufficient distance to catch any dampness that may trace down them. The top edge of iron forming drip should be finished with an iron frame, made of one-eighth by three-quarter-inch iron, extending around the back and ends of box, to this the top edge of iron should be securely and neatly riveted, keeping the iron frame on the inside next to ice box. There must be a space of not less than three-quarter inches between drip and bottom of ice box. Strips of some durable material, and of proper dimensions, may be introduced between drip and box bottom to preserve a uniform space. For protection the under side of drip will be cased with one inch white pine boards, matched and dressed. The casing boards to extend across the car, resting on the cleat at front and ends. Both the casing and drip will be further supported by four iron straps made of one-quarter by one and one-half inch iron ; the straps will be secured at their front ends to the cleat, and extend back underneath the drip casing, and up the back of box a sufficient height to secure it thereto. Each sweating drip must have a waste pipe, the conducting tube to be gas pipe, having an inside diameter of one and one-half inches. The tube to extend from drip down through the car floor, about three inches below its under side.

Size and Position of Icing Doors.

9th. Icing doors are located central from either side, and from top of floor to bottom of door the measurement should be four feet. The dimension of door to be twenty-five inches wide by twenty-three inches high.

Tray in Ice Box.

10th. Each ice box must have a wooden tray, covering the entire bottom inside. The tray to be made of ash or oak slats, three inches wide by three-quarter inches thick. The slats to be supported and secured to four battens, two inches wide by three-quarter inches thick. The battens running with the length of the box.

Painting.

11th. Painting of body, trucks, figures, letters and emblems, to be uniform with Empire Line standard box cars, except that the position of the emblem will be changed, and have the lettering "Butter & Egg Car" painted in a circular form above it.

12th. For a full and clear understanding of any obscure passages that may occur in these specifications, reference must be had to the drawings, sample car, and also to oral explanation. The Empire Transportation Company reserve the right to change or modify any plans herein specified, as experience may demonstrate desirable.

SPECIFICATIONS

FOR GONDOLA CARS, EMPIRE TRANSPORTATION COMPANY, ADOPTED JULY, 1872. REVISED JULY, 1873, REVISED JULY, 1875.

First.—In these specifications reference is to be had to any accompanying drawings, and also to the sample car when furnished. These specifications to be followed when they differ from drawings or car, and they and the drawings to be followed when they differ from car. Builders in all cases do, by contracting to build, agree to indemnify and save harmless the Empire Transportation Company from all patent right claims.

The make and character of wheels, axles and springs to be determined by the Empire Transportation Company.

The Empire Transportation Company reserves the right to require changes from these specifications, drawings and sample car. No car will be considered as accepted until inspected and approved by the Company's Superintendent of Cars.

Second.—All material used in the construction of these cars to be of the best quality, and workmanship first-class.

All timbers must be dressed on all their sides, and conform to the sizes and character of wood hereinafter specified.

That portion of the floor immediately over the body bolster must be of dry white oak.

Third.—Dimensions of car body as follows:

Extreme length of main frame	36 ft.	3 in.
Length of box, in the clear	34 "	0 "
Width " "	8 "	6½ "
Height from bottom of side sill to top of plate	2 "	2 "

Side sills and centre stringers must not be gained at bolsters or transoms. Intermediate stringers are to be gained at bolster, and also transoms. Mode of gaining stringers shown on drawing. There must be a space between the side and floor of at least ¼ inch maintained by cast-iron washers.

Fourth—Each car to be fitted with two cast iron card cases, secured to side of car, as shown on drawing; also with a full set of bearing and draw-springs, and double mouth draw-heads. All bolt heads and nuts, coming on the inside of car, must be sunk flush with the inside surface.

Fifth.—Car wheels to be broad-tread, diameter thirty-three inches, fitted on hammered axles, four and three-eighths inches in diameter by six feet nine and one-half inches long. Wheels to be correctly fitted to gauge furnished by Empire Transportation Co.

The trucks to be uniform in style and construction with trucks under sample car, unless otherwise specified. Body truss rods to be provided with turn-buckles, or their equivalent. Drawheads to be made of wrought-iron, strengthened at back end, such as that made by Berry, Courtney & Wilson, Pittsburg, Pa.

Sixth.—The following directions are to be strictly observed in turning up each car axle; all inside angles are to be turned concave; the shoulder back of wheel seat must be turned entirely off with a gradual taper.

Finished size of axle as follows:

Extreme length	6 ft. 9½ in.			
Button on end of axle	4⅛ in. diam.	⅝ in. long.		
Journal	3¼ " "	5⅝ " "		
Space between wheel seat and journal	4⅛ " "	2 " "		
Wheel seat	4 3/16 " "			

Seventh.—Number of car to be stamped with three-fourths inch figures on ends of body-bolster, and also on ends of truck bolsters.

Eighth.—All joints, tenons, and mortices to be coated with a solution composed of lime and sulphate of copper, to prevent decay.

Ninth.—End sills to be painted over their entire external surfaces. Ends of side sills and stringers to be coated with paint, about one foot back from end sills, before the box has been erected. The surfaces of side sills to be thoroughly coated with paint their entire length.

Cars to be painted with yellow oxide. Emblem, vermillion red on white field, of size and position shown on drawing. Eight inch white letters and figures on side of car, unfinished block, and six inch figures on ends, same style and color.

Tenth.—Cars to have brakes on each truck, connected with equalizing lever, as shown on drawing and sample car.

Eleventh.—Cars to have the patent Oil Box Lid manufactured by Kinzer & Jones, of Pittsburg, Pa.

Twelfth.—Cars to have Phospher Bronze Bearings and Malleable Iron Brake Shoes.

Thirteenth.—All Bolts and Nuts to be fitted with the Cummings Lock Nut Patent.

QUESTIONS ON THE THIRD CHAPTER.

Page 55. What is a specification? What should it contain? Mention the principal elements in the specifications for the Harbor Improvements at Cedar Keys.

Page 56. What additional dataarenecessary to complete the information to bidders? What precautions are taken to prevent fraud?

Page 57. State the elements in the S. for a Stone Breakwater at Block Island. What is rip rap? What a spar derrick? Give any reasons that may suggest themselves for the several restrictions in this S.

Page 59. Analyze the S. for a Breakwater of Cribwork at Cleveland. Define shakes, counterhewed, assemble, drift bolt, mauled. What are the elements in the S. for the Iron Landing Pier at Lewes, Del? Give the requirements in the case of the shafts, braces, forgings, castings, testing and delivery. Define swedged, scarf, turn buckle, body bound, lugs, etc.

Page 63. What are the contents of the S. for Removing Snags from the Minnesota River? Define snags. How are measurements made?

Page 64. What are the general divisions of the S. for the Tennessee River Improvement? How are the bids to be made in this case? What is the object of sections 6, 7 and 9? What allowance is made for extra haul? What is the object of provision No. 22? What is to be understood by earth excavation, hard pan, and loose rocks, solid rock, and old masonry? How is the masonry classified? and define each variety. How is it to be bid for? Mention the precautions enjoined in laying the masonry. What is the object of the 31st requirement? What proportion of sand is to be used with the cement and water? Define grouting, bond, hollow quoins, mitre sill, pitched, bush hammered, spalling, pointed down, "constructive measurement." What conditions must be fulfilled in the ingredients of the cement and in the sizes of the stones and their bond? How is the concrete composed and what instructions are given for mixing? Where may it be used?

Page 71. Where is the dam located for which S. are given on this page? State its dimensions, form of cross-section, and general arrangement. What should the bids include? What distinction is made between rock and earth excavation? Of what is the puddling composed and how laid? What are coffer dams? How are the foundations to be prepared? State the requirements of the stone work. In making concrete what proportion, by bulk, of the ingredients is prescribed? How are the slope walls to be laid? State the requirements in the case of the rip rap, cement, sand and mortar. What are the requirements for laying masonry, and for the timber work?

How are the various materials to be measured? Mention some of the general conditions. What are the terms of payment? What provisions are made in case of failure?

Page 77. Describe the manner of arranging the foundation for the South West Ledge Light-House, Long Island. Give a general description of the building with the means of access. Define templet, tap screw, tap bolt, channel and angle-iron, cleat, parting strip, jamb, lintel, architrave, rebate, countersunk, pilaster, frieze, plancier, fuscia, stop bead, ogee, hood, diamond checkers, shanks, soffits, purline strips, pinnacle. Under what heads are the items in the S. for a Sewer arranged? What are the conditions in case of ordinary excavation? what for rock work, refilling, embankment brickwork, stone masonry of the various kinds indicated? What are the provisions for making and mixing mortar, concrete? Describe the method of preparing the piles and timber foundations. How are the manholes to be constructed? connections with sewers how made? What general conditions are imposed? Define the technical terms found in these S. What are the stipulations concerning the execution of work, materials, and labor, interference with travel and works, damages and penalties, and payments?

Page 110. Give the general divisions of the S. for a college building. What special provisions are made in the case of the excavation?

Page 111. Of the stonework?

Page 113. Brickwork? Define footings, broken range rock work, water table, square droved, cornices, gables, belt courses, drafted, chamfered, reveal, stripping grounds, raked out, dashed and broomed, girder, beam, struck joints, parget, haunches.

Page 114. Describe the nature of the wood and carpenter work. Give the dimensions of the studs. What is meant by bridged?

Page 115. How is the wall plate secured? (Note.—The student should analyze in this manner the remainder of these specifications.)

Page 142. In the S. for a wrought iron bridge, what conditions are required for the wrought and cast-iron? How are the bids to be rendered?

Page 150. What is included under the head of Graduation? How are all cuttings to be measured? What are included under the heads of earth, loose rock, and solid rock?

Page 151. What are the prescribed widths of road bed for the several kinds of cuts and fills? the slopes? State the conditions given for removing material. What becomes of the excess of excavation or waste? How much ground should be cleared and why? Define slashed and term ditch. What disposition is to be made of valuable rock or timber removed from the line? What are the stipulations relative to a change of location or grade?

Page 152. How is travel on common roads provided during construction in their vicinity? How is the masonry classified? What are the least dimensions for a box culvert? How are foundations to be arranged? The abutment walls and covering are how built? How must foundations for

arched culverts in compressible soils be arranged? What kind of masonry is prescribed for the walls? What bond? Describe the foundations for bridge masonry? What are the three classes?

Page 154. Describe rock range, range and rubble. What are the conditions in the case of vertical and sloping retaining walls? State the general requirements.

Page 155. The bids are to include what? Define rip rap and its use. Give the stipulations in case of delay and extra work. State the requirements for sills when used in the superstructure.

Page 156. For cross-ties, chairs, and joints and rails. How is the track to be laid, and what allowance should be made for expansion of rails?

Page 157. What are the stipulations concerning the delivery of materials? How are fences to be constructed and paid for?

Page 158. What are the conditions relating to a change in the amounts of work, concerning workmen, monthly estimates and extra work? May sub-contracts be entered into? &c.

Page 161. How is tunnel work classified? What are the neat lines? What disposition is to be made of the excavated material? What should the estimate per cubic yard include! How are shafts to be paid for?

Page 162. What is a perch of masonry in these S.? What are the requirements for masonry? How are the faces to be trimmed? What recesses and opening are to be provided and why? Describe the arch work of stone, of brick.

Page 163. What is the backing, and how is it laid? How are the approaches to be finished? How are the shafts to be finished up? What provision is made for drainage? Who provides the lime and cement used and why.

Page 164. What is the contractor's duty in case of delay? What items are included under the general specifications for the Cincinnati Southern R. R.? What other items are to be included in the contract price for excavation?

Page 165. Describe the nature of the road and widths of road bed? How are excavations classified and define the subdivisions. How is the ditching paid for? What additional compensation is allowed when the hauling for road alterations, &c., exceeds the average distance? Where is the waste to be deposited? Spoil banks where? What is included in the item for excavation in water?

Page 166. What disposition is to be made of useful excavated material? Give the widths for the embankments inclination of slopes. State the restrictions when embankment is formed from ditches. How is the shrinkage provided for? What are the regulations for borrowed materials? How is macadamizing to be done?

Page 167. The price for tunnel work is composed of what items? How are the measurements to be made? Give the conditions in the case of shafts. What provision is made for falls? What are the requirements for

timbering and arching in brick? What provision is made for the escape of water?

Page 168. Note carefully the requirements in the various classes of masonry. Of what is the back filling composed? What should the prices for masonry include? for tunnel and shafts? How much is allowed per yard for hauls exceeding 500 feet?

Page 169. When may drain pipe be used and what conditions must it fulfill?

Page 170. What are the proportions for mixing cement mortar? How is masonry to be paid for? How are paved foundations to be arranged? timber?

Page 171. Give the required dimensions of piles and degree of penetration. How are payments to be made? How are bridges to be estimated? Mention some of the general conditions applicable to all work.

Page 173. What are the dimensions in the clear for through bridges? What test must they stand? Define camber.

Page 174. What are the limits of tensile and shearing strains? What factor of safety is used for compressive strains? Describe the quality of the iron to be used and its tests? also of castings? What are the maximum allowable errors of workmanship?

Page 175. How many coats of paint are required?

Page 176. What are the general conditions applicable to bridges and trestles?

Page 177. What final test is required? *Rails.* Mention the requirements for iron rails, method of manufacture, cutting, drilling, and straightening.

Page 178. How should they be marked, inspected and tested?

Page 179. What guarantee is required? *Bridge over the Ohio River*, C. S. R. R. Describe the foundations for the abutments, piers and draw pier. What is the bed rock?

Page 181. What proportions are required for the components of concrete?

Page 182. Give the dimensions in the clear of the bridge. What are the general specifications concerning the river navigation, risks, time, tests, estimates and changes?

The student should be required to prepare the specifications for any piece of work to be selected by the professor.

CHAPTER IV.

ADVERTISEMENTS.

Under this head it will only be necessary to give a few forms as guides to show what features should be prominently mentioned in such publications, and to call attention to the fact that all public works, whether for the Government, State, city, county, or borough, are generally required by law or ordinance, to be advertised for a certain length of time and to a certain extent before letting. In some instances the particular newspapers are mentioned, but generally those having the widest circulation are selected. It will be expedient for the engineer to inform himself as to the local requirements on this point before closing his contract, as legal objections have been sustained to contracts on the grounds that they were not properly advertised.

General instructions.

It should be remembered that the object of advertising is to bring into active competition all those who may be interested in and capable of performing a certain kind of work, and hence it should be done in such manner and localities, as to reach the greatest number of bidders. In general, the advertisements should be addressed to them as a class, as, e.g. "Proposals to Iron Manufacturers," "To Ship Builders," &c. The law as passed by Congress, 2d March, 1861, in relation to advertising for proposals for *Government* supplies or services, is as follows:-

Object of advertising.

Headings.

"All purchases and contracts for supplies or services in any of the departments of Government, excepting for personal services, shall be made by advertising, a sufficient time previously for proposals respecting the same, when the public exigencies do not require the immediate delivery of the articles or performance of the service. When immediate delivery or performance is required by the public exigency, the

U. S. law concerning advertisements.

articles or service required may be procured by open purchase or contract at the places and in the manner in which such articles are usually bought and sold, or such services engaged, between individuals."*

The advertisement should be concisely worded, and yet be sufficiently explicit as to the information required by persons desiring to bid, to prevent unnecessary delay. It should exhibit, when practicable, the *kind of work*, *material or service* required to be done or furnished; the *approximate amounts* of each as determined by the preceding estimate; the *time required* for its completion, the *place where* the labor is to be performed or the goods delivered; *when and where drawings*, or the work itself, may be inspected; any *general conditions* or instructions with which bidders are expected to comply; the *names and addresses of the parties* proposing to have the work done; the *time* before which all bids must be presented and the *manner of presenting them*, with any suggestions that may be deemed necessary.

What should be shown in the advertisement.

The manner of assembling these various items will be clearly illustrated in the carefully selected advertisements which follow. All of the *general conditions* need not be published as a part of the public advertisement, but should be printed upon the blanks delivered to bidders, as they form part of the requirements of the contract.

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* § 3709, Revised Statutes, U. S.

Advertisements for Proposals for U. S. Government Works.

*Under the direction of the U. S. Corps of Engineers.**

Harbor and River Improvements.

United States Engineers' Office,
No. 40 Church Street,
Mobile, Alabama,(1) April 7th, 1877.

Advertisement for dredging at Cedar Keys, Florida.

Sealed proposals, in duplicate[2] for dredging[3] 20,000 cubic yards, more or less,[4] through the bar at the mouth of the harbor of Cedar Keys, or in the channel between the bar and Cedar Keys, Florida,[5] will be received at this office[6] until 12 M., Tuesday, May 22, 1877,[7] and opened immediately thereafter.[8]

A guarantee will be required that within ten days after notification of the award of the contract, contract shall be entered into.[9]

Printed blank forms of proposals and guarantee, specifications, instructions to bidders, and any desired information can be had on application to this office.[10]

(Signed,)

A. N. DAMRELL,[11]

Captain Engineers, U. S. A.

See pages 55, 219, 251.

(1) Address. (2) Manner of Presenting. (3) Nature of work. (4) Amount. (5) Location. (6) Where addressed. (7) Bidding close. (8) Proposals opened. (9) Security required for beginning work. (10) General information. (11) Party letting work as agent for the United States.

Proposals for Rip Rap Granite.

Engineer's Office, U. S. A.,
Newport, R. I., Feb. 22, 1877.

For a Rip Rap.

Sealed proposals will be received at this office, until 10 o'clock A. M. on the twenty-second day of March, 1877, for Rip Rap granite for Breakwater at Block Island, Rhode Island.

Specifications in regard to the work, and blank forms for proposals and guarantee, upon which all bids must be made, will be sent on application to this office.

G. K. WARREN,

Major Engineers, and Brevet Major-General, U. S. A.

See pages 57, 219, 251.

* N. B.—For the corresponding *Specifications, Bids or Proposals and Agreements* accompanying these advertisements see the chapters on these subjects. They are separated here for purposes of classification and reference, but *all belong together and form essential parts of a complete contract.*

REMOVING OBSTRUCTIONS IN EAST RIVER AND HELL GATE, NEW YORK.

ARMY BUILDING, HOUSTON AND GREENE STS.,
NEW YORK, Oct. 5, 1876.

Sealed proposals in duplicate will be received until noon of October 18, 1876, for removing about 24 000 tons of broken rock from Hallet's Point Reef, Astoria, N. Y.

For dredging and grappling for rock.

Proposals will be received only from parties having machines capable of resisting collisions.

For forms of bids and other information apply at this office.

JOHN NEWTON,
Lieutenant-Colonel Engineers, Brevet Major-General.

See pages 58, 219, 251.

FOR BREAKWATERS AND PIERS.

ENGINEERS' OFFICE, U. S. ARMY,
No. 120 PEARL STREET,
BUFFALO, N. Y., March 26th, 1877.

Extension of Cleveland Breakwater.

Sealed proposals in duplicate addressed to the undersigned, will be received at this office until ten o'clock A. M. Monday, May 7th, 1877, for the extension of the shore-arm of the Cleveland Breakwater.

Bids for iron material will be entertained from iron dealers only; other bidders must bid for each and every item, excepting iron.

Further information, with printed forms upon which all bids must be made, can be obtained at this office.

Approximate Quantities of Material.

175,000 ft. b.m. Hemlock Timber.
140,000 " " Pine Timber and Lumber.
1,500 cords Rubble Stone.
1,000 tons Block Stone.
1,500 lbs. Screw Bolts.
25,000 " Drift Bolts.
2,200 " Spikes.

C. E. BLUNT,
Lieut. Col. of Engineers, U. S. A.

See pages 59, 219, 251.

IRON FOR LANDING PIER NEAR LEWES, DELAWARE.

U. S. ENGINEERS' OFFICE,
No. 1328 CHESTNUT STREET,
PHILADELPHIA, Pa., March 31, 1877.

Sealed proposals in duplicate will be received until 12 o'clock, noon, of Monday, the 16th day of April, 1877, for iron for this work.

For an iron landing pier.

Drawings can be examined and further information obtained at this office.

J. D. KURTZ,
Lieut. Col. of Engineers.

See pages 61, 219, 251.

REMOVAL OF SNAGS, &c., FROM THE MINNESOTA RIVER.

U. S. ENGINEERS' OFFICE,
ST. PAUL, Minn., June 2, 1877.

Duplicate sealed proposals will be received by the undersigned until 2 o'clock P. M., July 2, 1877, for the work of removing snags, &c., from the Minnesota River. For removal of snags, &c.

For all information apply to

F. U. FARQUHAR,
Major of Engineers.

See pages 63, 219, 251.

TENNESSEE RIVER IMPROVEMENT,

Muscle Shoals Canal.

U. S. ENGINEERS' OFFICE,
CHATTANOOGA, Tenn., April 18, 1877.

Sealed proposals in duplicate will be received at this office until noon, on Tuesday, May 15, 1877, for the building of five locks on the Muscle Shoals Canal, Tennessee River, about eight miles above Florence, Alabama. For five canal locks.

For specifications and forms of proposals, apply to this office.

W. R. KING,
Captain of Engineers.

See pages 64, 219, 224, 251.

KANAWHA RIVER IMPROVEMENT.

Proposals for Building a Dam on the Great Kanawha River.

U. S. ENGINEERS' OFFICE,
BALTIMORE, Md., March 1, 1877.

Proposals for building a dam on the Great Kanawha River, West Virginia, near Cabin Creek, will be received until noon of April 5, 1877, and opened immediately thereafter. For building a dam

Blank forms, specifications, can be had on application at this office.

WILLIAM P. CRAIGHILL,
Major of Engineers.

See pages 71, 219, 225, 251.

The following is the general form of advertisement in use in the United States lighthouse establishments:—

TO IRON MANUFACTURERS.—ADVERTISEMENT FOR PROPOSALS, FOR THE METAL WORK OF THE SUPERSTRUCTURE OF A LIGHT-HOUSE.

To be Erected at South-west Ledge, Long Island Sound.

OFFICE OF THE LIGHT HOUSE BOARD,
Washington, D. C., ...1875

Sealed proposals will be received at the office of the Engineer of the Third Light-house District, Tompkinsville, Staten Island, N. Y., until.......... o'clock of.. Time of opening.
...., 1875,

from iron manufacturers only, for furnishing the materials and labor of all kinds necessary for the completion of the metal-work of the superstructure of a light-house for Southwest Ledge, Long Island Sound, in accordance with the accompanying specifications and drawings. Nature of work.

The same to be delivered, at the expense of the contractor, on board of a sea-going vessel or vessels at.............................. Place of delivery.

The Light-House Establishment will provide the wood-work, the lens, the lamps, and furniture belonging thereto, and their cost is not to be included in the amount of the bid. Items excluded.

The bid should state the sum, in United States currency, for which the *entire metal-work*, as shown on the drawings and described in the specification, will be completed, fully erected at the workshops, then taken down after acceptance, and delivered as aforesaid, and should also state the day and date on which it shall be so completed and delivered, under forfeit, as specified in the "Form of bid." Price and conditions of acceptance.

The work will be carried on under the personal supervision of an agent of the Light House Establishment, and all facilities must be afforded him for inspecting the material and workmanship. Such parts of either as are not in accordance with the drawings and specifications must, in case of rejection, be made good at the expense of the contractor. Inspection.

The right is reserved to reject any proposal for any reasons deemed sufficient. Right to reject.

Each bid must be accompanied by a bond, signed by the bidder and two competent sureties, in the sum of five thousand dollars, that, in the event of the acceptance of such bid, the necessary contract will be entered into within ten days after notice is given that the bid has been accepted. Accompanying bond.

Bond and security in the sum of five thousand dollars, signed by two competent bondsmen, for the faithful performance of the contract, will be required. Security.

A copy of the plans and specifications must be inclosed with the bid, as evidence as to the object of the proposal. A copy of plans to accompany.

All proposals must be signed, sealed, and indorsed "Proposals for the metal-work of the superstructure of a light-house for (Southwest Ledge, Long Island Sound,") and then inclosed in another envelope, and directed, prepaid, to the Engineer, Third L. H. District. Indorsement.

Any bidder may be present and witness the opening of the bids at the time and place hereinbefore specified. Bidders may be present at opening.

Payments for the work will be made upon estimates certified to by the agent of the Light-House Establishment; but twenty per centum of the amount of each estimate will be withheld until the satisfactory completion of the contract. Payments and drawbacks.

Plans, specifications, and forms of proposals may be obtained from Gen. I. C. Woodruff, Engineer of the Third Light-House District, Tomkinsville, Staten Island, N. Y.; from Col. F. Harwood, Light-House Engineer, Baltimore, Md.; or from the undersigned.

For information apply to

See pages 77, 227, 254.

PETER C. HAINS,
Major of Engineers, U. S. A.,
Engineer-Secretary Light House Board,
Washington, D. C.

To Iron Manufacturers.—Proposals for the Metal Work and Erection of Two Lighthouses, to be Known as Liston's Tree Range Lights, Delaware Bay.

Office of Lighthouse Engineer, Fourth District,
Walnut Street,
Philadelphia, April 18, 1876.

Sealed proposals in duplicate will be received at this office, until 12 o'clock M., Monday, May 13, 1876, from iron manufacturers only, for furnishing all the metal work of superstructures, and for the erection of the same, for two lighthouses to be known as Liston's Tree Range Lights, Delaware Bay.

For two iron structures for range light

The right to reject any or all proposals, or to waive defects, if it is deemed for the interests of the United States to do so is reserved.

Drawings and specifications furnished on application at this office.

By order of the Lighthouse Board.

W. F. RAYNOLDS,
Brevet Brigadier-General, Engineer 4th L. H. District.

Advertisements for Municipal Works.

See pages 90, 230, 235. 259.

Department of Public Highways,
Office, S. E. Corner Sixth and Chestnut Streets,
Philadelphia, April 17, 1876.

Notice to Contractors.

Sealed proposals will be received at the office of the Chief Commissioner of Highways, until 12 o'clock M., on Wednesday, April 19th inst., for the construction of a sewer on the line of

New Street from Second to Fourth.

Hamilton Street from Twenty-third to Twenty-fourth.

Montgomery Avenue, from Woodstock to Uber Streets.

Each with a clear inside diameter of three feet. Said sewers to be constructed of brick, circular in shape, and in accordance with specifications prepared with the Chief Engineer and Surveyor, with such manholes as may be directed by the Chief Engineer and Surveyor. And the contractor shall take bills prepared against the property fronting on said sewer to the amount of one dollar and fifty cents for each lineal foot of front on each side of the street, as so much cash paid; the balance as limited by ordinance, to be paid by the city; and the con-

For three feet brick sewers, with manholes, &c.

tractor will be required to keep the street and sewer in good order for three years after the sewer is finished.

When the track is occupied by a city passenger railroad track, the sewer shall be constructed alongside of such track, in such manner as not to obstruct or interfere with the safe passage of the cars thereon; and no claim for remuneration shall be paid the contractor by the company using said track, as specified in Act of Assembly, approved May 8, 1866.

Each proposal will be accompanied by a certificate that a bond has been filed in the Law Department as directed by Ordinance of May 25th, 1860. If the contractor to whom the work is awarded shall not execute a contract within five days after the work is awarded, he will be deemed as declining, and will be held liable on his bond for the difference between his bid and the bidder to whom the contract may be awarded. Specifications may be had at the Department of Surveys, which will be strictly adhered to. The Department of Highways reserves the right to reject all bids not deemed satisfactory. No bid will be received from any bidder or bidders unless known to be skilled and regularly engaged in the construction of sewers.

All bidders may be present at the time and place of opening said proposals.

WM. BALDWIN,
Chief Commissioner of Highways.

DEPARTMENT FOR SUPPLYING THE CITY WITH WATER,
CHIEF ENGINEER'S OFFICE, N. W. Corner of Thirteenth and Spring Garden Streets
Philadelphia, April 10, 1876

For trenches for water pipes and excavating for foundation of engine house

Sealed proposals will be received at this office for each of the following items until Tuesday, April 18, 1876, at 3 o'clock P. M., to be opened in the presence of the Water Committee of Councils:

First. For the excavation and back-filling of a trench for the thirty-inch pumping main from the engine-house of the Frankford Water Works, at Lardner's Point, to the reservoir at the Wentz Farm, Twenty-third Ward.

Second. For the excavation and back-filling of a trench for the twenty-inch distributing main from the reservoir at the Wentz Farm to the Seven Stars Hotel, Frankford.

Third. For the excavation of the foundations of the engine and boiler house and stack at Lardner's Point, on the Delaware; for the pile-driving and foundation of the engine and boiler house and stack, the foundations for the engine and air-chambers, the forebay walls, the arched conduit, and the construction of the wharf and inlet channel.

Specifications and blank forms for proposals will be furnished upon application at the Chief Engineer's office, and no proposal will be received unless written upon such blank. Each bid must be accompanied with a certificate that a bond of $500 has been deposited with the City Solicitor as per ordinance of May 25, 1860, and the successful bidder will be required to furnish security in one half of the amount of the contract, as per ordinance of July 5, 1870. The committee reserve the right to reject any or all bids.

W. H. McFADDEN, *Chief Engineer.*

DEPARTMENT OF HIGHWAYS, BRIDGES, SEWERS, ETC.
OFFICE OF THE CHIEF COMMISSIONER, S. E. COR. SIXTH AND CHESTNUT STS.,
PHILADELPHIA, April 4, 1876.

*Notice to Bridge Builders.**

Sealed proposals will be received at this office until 12 o'clock M., Saturday, April 8, 1876, for building a bridge over Paper Mill Run at West Walnut Lane, in the Twenty-second ward. Proposals must state the time in which to complete the work, and be accompanied by a certificate that a bond has been filed in the Law Department, as directed by ordinance of May 25, 1860.

For a bridge over a run.

Plans, specifications, and form of proposal may be examined at the Department of Surveys, No. 224 South Fifth Street.

The city reserves the right to reject any and all proposals.

WILLIAM BALDWIN,
Chief Commissioner of Highways.

OFFICE OF THE BOARD OF COMMISSIONERS OF PILOTS,
No. 40 BURLING SLIP,
NEW YORK, Sept. 28, 1875.

Proposals will be received at this office until 12 o'clock noon of the 4th day of October, for the removal of so much of the pier and structures at Stapleton, S. I., heretofore erected and now maintained in the harbor of New York, by the New York and Staten Island Ferry Company, as are beyond the exterior line as fixed by law. Plans and particulars may be obtained at this office.

For removal of portion of pier at Staten Island.

By order of the Board, GEORGE W. BLUNT,
Secretary.

FAIRMOUNT PARK, OFFICE OF SUPERINTENDENT, BELMONT,
PHILADELPHIA, April 11, 1876.

Proposals will be received at this office until 12 o'clock M., 14th inst., for supplying 4,000 cubic yards good clear Fairmount gravel on Chamounix drive, West Park, from Belmont to Chamounix. To be delivered before May 6, 1876.

For 4,000 cubic yards of gravel for a drive.

RUSSELL THAYER,
Superintendent.

FAIRMOUNT PARK.—OFFICE OF SUPERINTENDENT,
BELMONT, April 8, 1876.

Proposals will be received at this office until 12 M., 11th inst., for depositing about 6,000 cubic yards of material† on Thirty-fifth street, near Girard avenue bridge; same to be obtained from the lot of ground on south side of Girard avenue, between Connecting Railroad Bridge and Junction Railroad bridge, and the work to be done in twenty days.

For 6,000 cubic yards of material.

RUSSELL THAYER,
Superintendent.

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* This advertisement is too vague. The nature of the bridge, whether of wood, iron or stone, and the kind of service, whether foot, road or railroad, should be stated.

† The material intended is that found on the lot within the specified limits.

Proposals for Stone.

Sealed proposals will be received at the office of the trustees of the New York and Brooklyn bridge, No. 21 Water Street, Brooklyn, until 12 o'clock noon, Saturday, October 9, for the delivery of 1,000 cubic yards cut face stone, and 731 cubic yards arch stone, all of limestone; also for the delivery of 85 cubic yards of granite corners, 250 cubic yards granite face stone, and 31 cubic yards granite arches.

For stone for East River Bridge abutments.

Printed specifications may be had at this office. Plans may be seen at engineer's office, corner Cherry and Dover streets, New York city.

UNITED STATES CENTENNIAL COMMISSION,
INTERNATIONAL EXHIBITION, PHILADELPHIA, 1876.

Proposals for Furnishing Steam-power.

Manufacturers of steam machinery are invited to send to the Director-General of the International Exhibition, at the office of the Commission, No. 904 Walnut street, until Saturday, April 10, 1875, propositions for one or more stationary engines, with or without boilers, for driving the machinery in Machinery Hall. No engine for this purpose of less than 180 horse-power will be accepted.

Proposals will state

1. Diameter of Cylinder.
2. Length of stroke.
3. Number of revolutions per minute.
4. Diameter and width of driving pulleys.

It is estimated that 1,400 horse-power will be required for the uses of the Commission.

Proposals will also be received for boilers without the engines, to be capable of safely withstanding a working pressure of 100 pounds per square inch above the atmosphere. All proposals will be required to specify distinctly whether the foundations are included.

Proposals will also be received for sixteen lines of shafting, including hangers and couplings, for driving the machinery in Machinery Hall, each line of shafting to be 650 feet in length, and to transmit 180 horse-power. to be applied at tbe middle of the shaft, the bearings to be 8 feet apart. There will be twelve lengths of this shafting to run at a speed of 120 revolutions, and four lengths to run at a speed of 240 revolutions per minute, the diameter of the shafts, exclusive of "head" and "second" shafts, will be 3 and 2½ inches respectively.

Proposals in all cases must state the terms and conditions upon which machinery will be furnished, with estimated cost of running the same during the Exhibition, on a basis of being in operation seven hours a day.

The main steam, water and drain pipes will be furnished by the Commission, but the party furnishing engines or boilers will be required to supply all connecting pipes. All of the above-mentioned machinery, including boilers, to be transported, set up in place, kept in place, and removed at the

close of the Exhibition at the expense of the exhibitor. Engines, boilers and shafting to be in place ready for use by the 15th day of January, 1876.

All articles accepted and furnished will be subject to the control of the Commission from the 15th of January, 1876, until the close of the Exhibition. Such articles will be considered as having been entered for exhibition.

The Centennial Commission reserves the right to reject any or all propositions that may be made in answer to this circular.

A. T. GOSHORN,
Director-General.

JOHN S. ALBERT,
Chief of Bureau of Machinery.
Philadelphia, March 18, 1876.

BUREAU OF MACHINERY.

UNITED STATES CENTENNIAL COMMISSION,
INTERNATIONAL EXHIBITION, Philadelphia, 1876.

Proposals for Furnishing Shafting.

Manufacturers of machinery are invited to send to the Director-General of the International Exhibition, at the office of the Commission, No. 903 Walnut Street, until 4 o'clock, P. M., Saturday October 15th, 1875, propositions for one to eight lines of shafting, including hangers, couplings, and main driving and guide pulleys, for supplying power in Machinery Building; seven lines of shafting to be six hundred and twenty-four feet in length, and to transmit one hundred and eighty horse power, and one line to be three hundred and fifty-two feet in length, and to transmit one hundred and twenty horse power, to be applied at the ends of the shafts, the bearings, except for the head shafts, to be eight feet apart; hangers to have thirteen inches drop, except those for the head shafts, which will be eleven inches.

There will be seven lengths of this shafting to run at a speed of one hundred and twenty revolutions, and one length to run at a speed of two hundred and forty revolutions per minute; generally, the diameters, exclusive of the "head" and second shafts, will be 3 and 2½ inches respectively.

All of the above mentioned machinery to be transported, erected, and removed at the close of the exhibition, at the expense of the exhibitor, and must be ready for use by the 1st of March, 1876.

If accepted, it will be subject to the control of the Commission, from that date until the close of the exhibition, and will be considered as having been entered for exhibition.

For more detailed information, parties wishing to make proposals will be furnished with "tracings" on application, by the Chief of the Bureau of Machinery.

The Centennial Commission reserves the right to reject any or all propositions that may be made in answer to this circular.

A. T. GOSHORN,
Director General.

JOHN S. ALBERT,
Chief of Bureau of Machinery.
Philadelphia, September 20, 1875.

QUESTIONS ON THE FOURTH CHAPTER.

Page 207. When and how should advertising be done? State the general conditions of the U. S. law.

Page 208. What information should the advertisement exhibit?

Page 209. Analyze the advertisements given in this chapter in a manner similar to that given on pages 209 to 214.

Page 215. Point out some of the defects in the advertisements for a bridge over a run, and for 6000 cubic yards of material.

The student should be required to prepare an advertisement for some construction to be selected by the Professor.

CHAPTER V.

Bids or Proposals.

Bids or proposals are offers, usually in writing, to do a certain act, or to perform a certain work for a consideration. Bids defined.

Bona fide bids are those made in good faith, and with the intention of fulfilling them. Genuine bids.

"*Straw*" *bids* are those presented over an assumed name, or by an irresponsible party for fraudulent purposes. Straw bids.

The engineer or agent letting the work is expected to prepare and furnish to the bidders blank forms, to be filled out by them, with instructions concerning the manner of so doing, time of presentation and opening, and whatever restrictions may be imposed upon parties desiring the work, with any other information deemed necessary. Engineer to prepare forms of bids and instructions.

The manner of filling out the blanks, endorsing the bids, and the general conditions to be complied with as required in all proposals for Government work, are fully set forth in the following "Instructions for Bidders," *which should always be attached to each blank proposal, and form part of the contract.* Filling out blanks for proposals.

Instructions for Bidders.

(Printed on same paper with specifications, &c.)

1. All bids must be made in duplicate upon printed forms to be obtained at this office, and enclosed in two envelopes. The outside envelope will be directed to the engineer in charge at this office; the inside one will be endorsed ("*Proposals for Dredging at Cedar Keys, Florida.*") Endorsing and addressing bids.

2. The guarantee attached to each bid must be signed by two responsible guarantors, to be certified to as good and sufficient guaranters by a United States district attorney, collector of customs, or any other officer under the United States government, or responsible person known to this office.

Guarantees to be certified to by a U. S. officer.

3. When firms bid, the individual names of the members should be written out, and should be signed in full, giving the Christian names; but the signers may, if they choose, describe themselves, in addition, as doing business under a given name and style as a firm.

Individual signarures of firms required in full.

4. All signatures must have affixed to them seals of wax or wafer.

Seals must be wax or wafer.

5. The place of residence of each bidder, surety and witness, with county and State, must be given after his signature, which must be written in full.

Places of residence stated in full.

6. Prices must be written as well as expressed in figures.

Prices written.

7. A percentage of ten (10) per centum, more or less, will be retained from each payment until the completion of the contract;* except where (as in case in which no payment is to be made until a work is completed) such percentage may, in the opinion of the officer in charge, properly be dispensed with.

Amount retained.

Exceptions.

8. The contract which the bidder and guarantors promise to enter into shall be, in its general provisions, and in use by the Engineer Department of the Army, blank forms of which can be inspected at this office, and will be furnished, if desired, to parties proposing to put in bids. Parties making bids are to be understood as accepting the terms and conditions contained in such form of contract.

Form of contract will be furnished.

9. Reasonable grounds for supposing that any bidder is interested in more than one bid for the same item will cause the rejection of all bids in which he is interested.

Fraudulent or straw bidding prohibited.

* Work.

10. The United States reserves the right to reject any and all bids; also to disregard the bid of any *failing bidder or contractor* known as such to the Engineer Department. Right to reject any bids

11. The bidder must satisfy the United States of his ability to furnish the materials or perform the work for which he bids. Bidders must be able to perform.

12. Payments for each month's work will be made as soon after the first of the month as practicable. Time of making payments.

13. Transfers of contracts or of interests in contracts, are prohibited by law.* Transfer of contract prohibited.

14. In submitting proposals, the sealed envelope must be so endorsed as to indicate before being opened the particular work for which the bid is made. Endorsing proposals

15. A bond of (an amount usually about one-third that of the contract) dollars, with two sufficient sureties, will be required to insure the commencement and completion of the work at the time stated. Security for the commencement of the work.

16. Proposals will not be received by telegraph at any time. No bids by telegraph.

17. Blank forms of proposals and guaranty must be properly filled out in regard to guaranty, price of doing work, time of commencement and completion, &c., exactly in the manner prescribed by them. Blanks must be properly filled.

18. Detailed maps of the locality can be seen at this office. Drawings to be seen at office.

19. A copy of this advertisement and specification will be attached to the contract and form part of it. Advertisements, &c., to form part of contract.

20. Bidders are requested to be present at the opening of the bids.† Bidders present at opening.

* § 3,737. Revised statutes, U. S. July 17, 1862.—No contract or order, or any interest therein, shall be transferred by the party to whom such contract or order is given, to any other party, and any such transfer shall cause the annulment of the contract or order transferred so far as the United States are concerned. All rights of action, however, for any breach of such contract by the contracting parties are reserved to the United States

† §3710 Revised Statutes of the United States. Whenever proposals for supplies have been solicited, the parties responding to such solicitation shall be duly notified of the time and place of opening the bids, and be permitted to be present either in person or by attorney, and a record of each bid shall there and then be made.

21. No award of the work above advertised will be made until the bill making the appropriation for the same has been passed by Congress, and approved by the President of the United States.

No work awarded before appropriations are made.

The object of these several provisions are so evident as to need no explanation. They are the results of a long experience, and are found to be necessary safeguards to ensure honesty and expedition in the execution of the contract.

The above provisions necessary.

The Guaranty provides that the contract shall be entered into within ten (10) days, more or less, of the time of making the award. This is to prevent irresponsible parties having no "plant" from entering, with the expectation that if successful they will procure an equipment on credit, or sell out to other contractors for a "bonus."

Object of the Guaranty.

Blank forms of Proposals as used in the U. S. Service with the Guaranty attached, are appended as guides.

Proposals of.............................. for

REMOVING SNAGS, &C., FROM MINNESOTA RIVER, OPENED JULY 2, 1877.

See pages 63, 211, 219, 251.

(TOWN, COUNTY, AND STATE)..

..............................1877.

I, (or) We, the subscriber , do hereby propose to do the work of removing snags, &c., from the Minnesota River, agreeably to the terms of your advertisement and specifications dated June 2d, 1877, (copies of which are hereto attached) relating to "Improvement of Minnesota River," in the manner and upon the terms specified below, viz.:

For removing Boulders.................................... dollars and ....cents, ($) per cubic yard.

For removing overhanging Trees from the banks, of the following dimensions, measured one foot above the roots:

For those thirty-six inches in diameter and upwards, ...dollars and......cents, ($) each.

For those thirty inches in diameter and upwards, not exceeding thirty-six inches in diameter,............ dollars and......cents, ($) each.

For those twenty inches in diameter and upwards, not exceeding thirty inches in diameter,............ dollars and......cents, ($) each.

For those six inches in diameter and upwards, not exceeding twenty inches in diameter,............ dollars and......cents, ($) each.

For those four inches in diameter and upwards, not exceeding six inches in diameter............ dollars and......cents, ($) each.

For removing Snags, Logs, Stumps, and Trees with roots imbedded in the bottom of the river, of the following dimensions, measured two feet above the roots:

For those thirty-six inches in diameter and upwards.............dollars and......cents, ($) each.

For those thirty inches in diameter and upwards, not exceeding thirty-six inches in diameter,............ dollars and......cents ($) each.

For those twenty inches in diameter and upwards, not exceeding thirty inches in diameter,............ dollars and......cents, ($) each.

For those six inches in diameter and upwards, not exceeding twenty inches in diameter,............ dollars and......cents, ($) each.

For those four inches in diameter and upward, not exceeding six inches in diameter,............dollars and......cents, ($) each.

I (or) We further propose to commence the work on or before the 1st day of April, 1878; and I (or) we pledge ....to enter into a written contract with the United States, with good and approved security, within the space of ten days after being notified that the foregoing bid has been accepted. Your obedient servant,

................................[L. S.]

.............................Witness.

Of the town of........county of........State of........

....[L. S.]

Of the town of........county of........State of........

....[L. S.]

Of the town of........county of........State of........

To MAJOR F. U. FARQUHAR,
Corps of Engineers.

Guranty.

We,........................of the town of............in the county of...........and State of.............and.............of the town of ....in the county of............and State of............ hereby, jointly and severally, covenant with the United States, and guarantee, in case the within bid of......................be accepted, that............will, within ten days after being notified of the acceptance of said bid, execute a contract of the character and form described in the accompanying General Instructions for Bidders, and in conformity with the advertisement and specifications dated June 2d, 1877, under which the bid was made, together with a bond, with good and sufficient sureties, in the sum of three thousand dollars; and in case the said........................

shall fail to enter into a contract as aforesaid, we guarantee to make good the difference between the offer by the said..........................and the next lowest responsible bidder, or the person to whom the contract may be awarded.

Given under our hands and seals this..........day of...........1877.

Witnesses:

....[L. S.]

....[L. S.]

I hereby certify that, to the best of my knowledge and belief, the above named guarantors are good and sufficient as sureties for the amount for which they offer to be security.*

The form of guaranty being the same for all Government proposals is not attached to any subsequent blanks.

Proposals of..for

BUILDING FIVE LOCKS ON THE MUSCLE SHOALS CANAL, TENNESSEE RIVER,

Opened May 15th, 1877.

See pages 64, 211, 219, 251.

(TOWN, COUNTY, AND STATE,)...

..................................187

I, (or) We, the subscriber , do hereby propose to furnish the materials and do the work required in building Lock No..............agreeably to the terms of your advertisement and specifications, dated April 18, 1877, (copies of which are hereto attached), relating to the building of locks on the Muscle Shoals Canal, in the manner and on the terms specified below, viz.:—

1. For earth excavation.....................cents (...) per cubic yard
2. For rock excavation.........dollars and....cents ($..) per cubic yard
3. For removal of old locks.....dollars and....cents ($..) per cubic yard
4. For cut stone masonry, set..dollars and....cents ($..) per cubic yard
5. For rock face masonry, set...dollars and....cents ($..) per cubic yard
6. For rubble masonry, laid....dollars and....cents ($..) per cubic yard
7. For concrete, laid..........dollars and....cents ($..) per cubic yard

Allowing the United States for stone taken from old locks, and used as—

8. Cut stone masonry.........dollars and....cents ($..) per cubic yard
9. Rock face masonry.........dollars and....cents ($..) per cubic yard
10. Rubble masonry...........dollars and....cents ($..) per cubic yard

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* To be certified by a U. S. District Attorney, Collector of Customs, or any other officer under the United States Government, or responsible person known to this office.

I, (or) We, have carefully read the foregoing specifications, and have informed............as to the nature of the work to be done.

I, (or) We, further propose to commence the work on or before the..... day of June, 1877, and to complete the same on or before the 30th day of June, 1878; and I, (or) we, pledge............to enter into a written contract with the United States, with good and approved security, within the space of ten days after being notified that the foregoing bid has been accepted.

Your obedient servant,

Witnesses:—

....Seal.

Of the town of...........County of...........State of...........

....Seal.

Of the town of...........County of...........State of...........

....Seal.

Of the town of...........County of...........State of...........

To CAPTAIN W. R. KING,
U. S. Corps of Engineers,
Chattanooga, Tennessee.

Proposal of..for

BUILDING A DAM ON THE GREAT KANAWHA RIVER.

Opened April 5th, 1877.

See pages 71, 211, 219, 251.

(TOWN, COUNTY, AND STATE),..

......................187

............the subscribers offer to furnish all the materials not furnished by the United States, and to do all the work necessary to construct and complete the earthwork and masonry of Dam No. 4, of the Kanawha River improvement, in conformity with the terms of your advertisement, dated March 1, 1877, and with the specifications herewith, with the plans, and with such directions as may from time to time be received from the engineer, for the following prices for finished work, viz:

Earth excavation per cubic yard....................................
Rock excavation " " ....
Puddling " " in place..............................
Concrete " " " ....
Coping " " laid..............................
Cut stone masonry " " " ....

Dressed rubble masonry per cubic yard, laid........................
Rock faced " " " " ....
Rough rubble " " " " ....
Slope wall, including lining, pet cubic yard, laid ....
Rip-rap per cubic yard.............in place.............................
Paving " " .... " ....
Timber and plank, per 1,000 feet, B. M., in place....................

The above prices include all materials, workmanship, labor, scaffolding, tools and machinery, and every expense necessary to the completion of the whole work.

In compliance with the specifications, we have visited either in person or by competent agent, the localities in question, and have made the investigations recommended.

........further propose to commence the................................ on or before the............day of.............187...., and to complete the same on or before the 31st day of December, 1878; and I [or] we pledge.................to enter into a written contract with the United States, with good and approved security, within the space of ten (10) days, after being notified that the foregoing bid has been accepted. Your obedient servant ,

WITNESSES:

....	....	[L. S.]
....	....	[L. S.]

Residences of Bidders.

....
Of the Town of...........County of............State of..............

....
Of the Town of............County of............State of..............

....
Of the Town of............County of............State of..............

To MAJOR WM. P. CRAIGHILL,
Corps of Engineers,
Union Bank Building, Baltimore, Md.

U. S. Light-House Bureau.

The forms in use in the U. S. Light-House Establishment differ somewhat from those of the Engineers. They are accompanied by a *guaranty* or *bond* as well as by the *oaths* of the *Bondsmen*, giving their pecuniary status and a certificate of a Government officer relative to the solvency of the bondsmen.

Requirements of the U. S. Light House Establishment.

Form of Bid.

See pages 77, 213, 254.

....

....

....

I, (or we,)........................., of the.................., State of ...., engaged in iron-manufacturing business under the name and style of.............................., hereby agree to furnish all the materials and labor necessary to completely construct, erect at the workshops, take down after acceptance, and deliver on board vessel, (except the woodwork, the lens, the lamps, and other furniture belonging thereto,) at.......... ....., the metal-work for the superstructure of the light-house for Southwest Ledge, Long Island Sound, in accordance with the accompanying specifications and drawings, the work to be completed and delivered on or before the............day of............, 187 , for the sum of................ $\frac{}{100}$ dollars, ($...... $\frac{}{100}$) in United States Currency; and .... further agree to forfeit the sum of twenty dollars per day, as liquidated damages, for each day's delay in completing the work after said date, said amount to be deducted from any sum due me (or us) in the hands of the agent of the Light-House Establisnment.

(Signed) ....[L. S.]

............................[L. S.]

............................[L. S.]

To GEN. I. C. WOODRUFF,

Engineer Third Light-House District,

Tompkinsville, Staten Island, New York.

Form of Bond With Bid.

Know all men by these presents, that we,............................and ...., citizens of....................are held and firmly bound unto the United States of America in the full and just sum of...... ....dollars, ($........,) lawful money of the United States, to be paid to the said United States, or to its proper agent or attorney duly authorized to receive the same, as liquidated damages; to which payment, well and truly to be made and done, we bind ourselves and every of us, our and every of our heirs, executors, and administrators, in the whole and for the whole, jointly and severally, firmly by these presents. Sealed with our seals and dated this.........of.........anno Domini one thousand eight hundred and seventy.....

The condition of the above obligation is such that if.................. ....and.................................. doing business under the name and style of...................their heirs, executors, and administrators, do, and shall well and truly, within ten days after notice of acceptance of...............bid, enter into contract for the construction of the metal-work for the superstructure of a light-house for Southwest Ledge, Long Island Sound, in accordance with the terms of.... ....bid dated.........., 187 , conforming in all respects to the advertisement dated.........., 187 , calling for proposals, the same being hereto annexed, then the foregoing obligation to be void and of none effect; otherwise, to remain in full force and virtue in law.

Signed, sealed, and delivered in the presence of—

Witnesses:

....	......................[L. S.]
....	......................[L. S.]
....	......................[L. S.]
....	......................[L. S.]

NOTES.—All signatures of bidders and sureties should have affixed to them seals of wax or wafer. The residence of sureties and witnesses should be given.
Bondsmen will qualify in double the amount of the bond, and will qualify in the forms following.

Bondsmen's Oaths.

STATE OF............................, }
County of.....................,} *ss:*

........................., being duly sworn, deposes and says that he resides at No......,.......street, in the...........of........... in the State of............; and that the value of his property, over and above

all debts and liabilities incurred by him, is over..................dollars, ($......,) and that he is fully responsible for the amount of his obligation in the foregoing bond by him executed.

....

Sworn and subscribed this........day of..........., 187 , before me.

........................[L. S.]

....

STATE OF........................, } ss:
County of...................., }

..............................., being duly sworn, deposes and says that he resides at No....., ...street, in the............of............in the State of................; and that the value of his property, over and above all debts and liabilities incurred by him, is over.................. dollars, ($........,) and that he is fully responsible for the amount of his obligation in the foregoing bond by him executed.

....

Sworn and subscribed this........day of........., 187 , before me.

......................,[L. S.]

....

Certificate of Solvency.

I certify that I have made due and diligent personal inquiry as to the ability of the signers of the foregoing bond, and am satisfied that they are good and sufficient, and fully responsible for the sum of.................. ....dollars, ($......) each.

....

....

Date:.....................

NOTES.—The sureties' certificate of solvency must be signed by an officer of the Government known to the Treasury Department.
Each surety will qualify in double the amount of the bond.

MUNICIPAL WORK.

The following bid is selected from a large number submitted for a sewer, and will serve to give some idea of the prices for that class of work.

Accompanying it will be found the certificate of the City Solicitor as required by the Ordinance of May 25, 1860, to which attention is called in the advertisement as published on page

DEPARTMENT OF SURVEYS, CITY OF PHILADELPHIA.

THE SNYDER AVENUE MAIN SEWER,

On Snyder Avenue, from Sixth street to Delaware Avenue, as authorized by Ordinance approved November 1, 1875.

To Contractors.

Proposals for the construction of the above work must be made upon the printed forms. They must have inserted the *signatures* of at least two responsible sureties, and also be accompanied by a certificate that a bond has been filed in the Law Department, as directed by Ordinance of May 25, 1860.

No proposal will be received from any contractor unless known to be skilled and regularly engaged in the construction of sewers.

Proposals which contain any omissions, erasures, alterations, additions not called for, conditional bids or irregularities of any kind, will be rejected as informal.

All prices must be written in words, and also stated in figures, and must be for the whole work.

Extra work, when necessary, will be done and paid for according to the estimate of the Chief Engineer and Surveyor.

Contractors must make themselves acquainted with the conditions of the ground, whether the foundations will be rock, hard earth, or soft bottom, so that they may make an intelligent bid.

Proposal.

See pages 90, 213, 259. PHILADELPHIA, June 14, 1877.

To the Chief Commissioner of Highways.—Sir:—I hereby propose to furnish all the labor and materials necessary to perform the whole of the work, and submit to all conditions as represented, intended and implied, both particularly and generally in the plans, specifications and form of agreement examined at the Department of Surveys, and also in the Ordinance approved November 1, 1875, "to authorize the construction of certain sewers," and perform all additional work that may be required, upon the following terms, to wit:—

For Sewer 5½ ft. in diam. per lineal foot, the sum of five dollars....$ 5.00
For Sewer 6 ft. in diam. per lineal foot, the sum of twelve dollars.... 12.00
For Sewer 6½ ft. in diam. per lineal foot, the sum of fifteen dollars... 15.00
For Sewer 7 ft. in diam. per lineal foot, the sum of twenty dollars... 20.00
For Sewer 7½ ft. in diam. per lineal foot, the sum of thirty dollars... 30.00
For Sewer 8 ft. in diam. per lineal foot, the sum of thirty dollars.... 30.00

And I hereby propose, as responsible sureties, the persons who have affixed their names to the annexed certificate, and who are willing to be

bound with me jointly and severally, in the sum of one-half the estimated value of the work herein proposed to construct, for the due and satisfactory performance of the whole work comprised in the contract, as well as of such additional works that may be ordered, and to complete the same within twelve (12) months after the date of the notice given by the Chief Engineer and Surveyor to begin work.

As witness my hand this twelfth day of July, 1877.

(Signed)

HUGH DEEHAN.

Address—Hugh Deehan, No. 1921 Hamilton Street.

Certificate of Sureties.

This certificate must be signed by two sureties.

We hereby certify that we are responsible sureties, and agree to be bound jointly and severally with the above-named Hugh Deehan, Contractor, in the sum of one-half the estimated value of the work herein proposed to construct, should this proposal be accepted.

(Signed)

JAMES DEEHAN,
No. 807 *North Sixteenth Street.*

CHARLES S. PANCOAST,
No. 1907 *Green Street.*

FRANCIS LOGUE,
No. 803 *North Eighteenth Street.*

LAW DEPARTMENT,
No. 212 South Fifth Street,
Phila., March 3, 1877.

THIS WILL CERTIFY:

That B. C. D. has complied with the ordinance of Councils, approved May 25th, 1860, "relating to proposals for work and materials," and has filed his bond with the requisite security, in $500, conditional that if his bid for the construction of a sewer on .... Street .... is the lowest, and he shall decline to do the said work or furnish said materials, then he shall pay to the city the difference between the amount of his bid and the bid of him or them who shall actually perfotm said work or furnish said materials.

W. N. A.
Assistant City Solicitor.

PROPOSALS FOR RAILROAD GRADUATION AND MASONRY.

See pages 150, 280.

The accompanying form of proposal is that in use at present upon the Pennsylvania Railroad and its branches. The prices are also written out in full in the contract of which this is a part, see page 220.

Proposals for Grading and Masonry of the...*Railroad.*

Number of Section.	EXCAVATION & EMBANKMENT Per Cubic Yard.				MASONRY—PER PERCH.									Grubbing and Clearing per Acre.	Slashing per Acre	Timber in Foundation per cubic foot.
	Earth.	Loose Rock.	Solid Rock.	Embankment.	Rectangular Culverts.	Arched Culverts.	Bridge, 1st Class.	Bridge, 2d Class.	Bridge, 3d Class.	Paving.	Vertical Wall.	Slope Wall.	Rip-Rap			
	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.

The undersigned hereby propose to the...Railroad Company, to do all the work on either or all of the Sections to which prices are affixed in the above Schedule, according to the conditions and specifications contained in the printed form of Contract, a copy of which is attached to this Proposal; and on the acceptance of this Proposal, for all or either of the above Sections, do hereby bind...to enter into and execute a Contract in said form for said work, at the prices above named.

....

....

...., 187 ....

Proposer's Residence,...

Nearest Post Office,..

CINCINNATI SOUTHERN RAILWAY. Also, that he ha carefully

either or all the Sections, to which prices are affixed in the Schedule, according to execute a contract for the work at the following prices :—

	Macadamizing.		Drain Pipe.			Foundations.			Wood Trestles		Girder Bridges	
	Per Cubic Yard.		Per L. t.			perMBM	per lb.	perLft	perMBM	per lb.	perMBM	per lb.
Concrete.	Macadamizing.	Removing old Turnpike metal.	12 Inch.	15 Inch.	18 Inch.	Timber in Foundations.	Iron Work.	Piles.	Timber.	Iron.	Timber.	Iron.
$ cts.	$ cts.	$ cts.	cts.	cts.	cts.	$ cts.	cts.	cts.	$ cts.	cts.	$ cts.	cts.

......day of..................................187

....Name of Firm.

By ....

....

....

PROPOSAL.

The undersigned hereby certif , that he ha personally and carefully examined the Sections named in the bid below, on Division of the CINCINNATI SOUTHERN RAILWAY. Also, that he ha carefully examined Profile and Specifications of the same.

Having made such examinations, the undersigned hereby propose to the TRUSTEES OF THE CINCINNATI SOUTHERN RAILWAY, to do all the work specified, on either or all the Sections, to which prices are affixed in the Schedule, according to Conditions and Specifications aforesaid, and on the acceptance of this Proposal for either or all of the following Sections, do hereby bind to enter into, and execute a contract for the work at the following prices:—

No. of Section and Division.	GENERAL EXCAVATION.						Embankment per cubic yard.	TUNNEL WORK.						MASONRY.													MACADAMIZING.		DRAIN PIPE.			FOUNDATIONS.			WOOD TRESTLES		GIRDER BRIDGES	
	Per Cubic Yard.							Per Cubic Yard.						Per Cubic Yard.													Per Cubic Yard.		Per L. t.			per MBM	per lb.	per Lft	per MBM	per lb.	per MBM	per lb.
	Earth Excavation	Hard Pan.	Loose Rock.	Solid Rock.	Iron Ore.	Excavation in Water		Tunnel Excavation.	Shaft Excavation.	Brick Work.	Concrete Packing.	Dry Packing	Timbering per 1000 feet B. M.	1st class Bridge Masonry	2d class Laid dry.	2d class in cement	1st class Arch Masonry	2d class Laid dry.	2d class in cement	Box culv. Masonry Dry.	Box culv. in cement	Slope Walls.	Rip Raps	Stone Paving	Brick Work.	Concrete.	Macadamizing.	Removing old Turnpike metal.	12 Inch.	15 Inch.	18 Inch.	Timber in Foundations.	Iron Work.	Piles.	Timber.	Iron.	Timber.	Iron.
	cts.	cts.	cts.	cts.	cts.	cts.	cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	$ cts.	cts.	cts.	cts.	$ cts.	cts.	cts.	$ cts.	cts.	$ cts.	cts.

The undersigned further propose to commence work within........................ days from date hereof.

Signed this.................................... day of.................................... 187

.... Name of Firm.

References:

....

....

....

Post Office Address of Contractor,

....

By ....

....

....

Proposal for Tunnel Work on the.. ....Railroad.

Number of Section.	Tunnel Excavation per Cubic Yard		Sinking Shafts per ft. Vertical.		Haul per yd. per 100 feet, over ....Ft.		MASONRY PER PERCH OF 25 CUBIC FEET.											
							Abutments.		ARCH WORK				Backing.		Facade and Approaches.		In Shafts.	
									Stone.		Brick.							
	$	cts.	$	cts.	$	cts.	$	cts.	$	cts.	$	cts.	$	cts.	$	cts.	$	cts.

The undersigned hereby propose to the..Railroad Company, to do all the Tunnel work on either or all of the Sections to which prices are affixed in the above Schedule, according to the conditions and specifications contained in the printed form, a copy of which is attached to this proposal; and on the acceptance of this Proposal, for all or either of the above Sections, do hereby bind.................... ....to enter into and execute a Contract for said work, at the prices above named.

....

....

...., 187 ....

Proposer's Residence...

Nearest Post Office ....

Proposal for the Superstructure of an Iron Bridge.

Office of the Keystone Bridge Co.,
Philadelphia, Dec. 24, 1873.

Robert H. Sayre, Esq.,
Chief Engineer, E. & A. R. R.:

The Keystone Bridge Company respectfully submits the following proposition for the manufacture and erection of a first-class wrought-iron bridge on the Easton & Amboy R. R., across Morris Canal and Lopatcong Creek; as per the accompanying diagram of strains and the following specifications:

Bridge to be of double track, of span as given on profile sent us.

Bridges to be proportioned to sustain a variable load of 3000 lbs. per lineal foot per track, on the chord system and 3,500 lbs. per lineal foot on the panel system, in addition to the dead weight of structure with the following strains on materials, viz:

Tensile strains	10,000	lbs. per square inch.
Compression, upper chord	8,000	" " "
" posts	7,500 to 7,000	" " "

The iron to be of best quality bridge iron of an ultimate tensile strength of 55,000 to 60,000 lbs. per sq. inch, tested in usual way.

Track to be carried on wrought-iron cross girders with heavy longitudinal stringers and cross ties.

Through span to have suspended cross girders at each post, wooden stringers and cross ties.

Upper chords to consist of rolled channels, with top plate open on under side to admit of repainting on inside.

Posts to be Linville patent, also made open to admit of repainting on interior.

Lower chords, our patent weldless links.

Caps and bases of posts to be of cast-iron.

Deck spans to have no end posts, but to be supported by masonry carried to upper chords.

Through span to have inclined end posts and upper lateral bracing. All lateral struts to be of wrought-iron.

Price for the bridge erected complete ready for the cross ties; iron work painted one coat, will be as follows:

Two deck spans 146·05 ft. clear, $22,300 each	$44,600.00
One through span, askew, 66.75 ft. on centre line	6,500.00
Total	$51,100.00

The company to prepare masonry to suit plans and remove any existing structure, and furnish and lay cross ties.

We have assumed that there is railroad communication to bridge site.

Payments to be made monthly on material delivered at our works and work in progress, ten per cent. being retained until completion. We can execute the work promptly and have the bridge completed in time specified,

I am, yours very respectfully,

April 15, 1874.

J. H. LINVILLE,
President.

Opening the Bids.

Proposals to be publicly opened.

All proposals should be opened publicly, and in the presence of any bidders who may desire to attend, that there may be no opportunity for a charge of unjust discrimination, or for the suppression of any of the bids.

Method of proceeding.

At the time appointed in the advertisement, the parties authorized by law to examine and compare the bids, having assembled at the proper place, with such of the bidders or their proxies as may desire to be present, the "sealed proposals are then opened one by one, and the contents read aloud that all present may take notes. The parties letting the work enter the several prices bid in a tabular form and proceed to determine the aggregate. If the number of proposals be numerous or the work extensive, this operation may continue several days, in which case the bidders may disperse after hearing the prices read, and await the announcement of results. It frequently happens that young and inexperienced contractors, to secure a piece of work will put in a bid at such low figures that it would be impossible to execute it at that price, and the attempt would only result in loss and delay to the operators. For this and other reasons, the clause reserving the right to reject any or all bids if deemed necessary has been introduced.

Bids for Snyder Avenue Sewer, Philadelphia.

In opening the twelve proposals made for the construction of the Snyder Avenue Sewer, (see

page 230), the prices bid were read out, and the results then tabulated as follows:—

Nos. of Proposals.	NAMES OF BIDDERS.	Months' time in which to do the work.	Price per lineal foot for 5½ feet diameter.	Price per lineal foot for 6 feet diameter.	Price per lineal foot for 6½ feet diameter.	Price per lineal foot for 7 feet diameter.	Price per lineal foot for 7½ feet diameter.	Price per lineal foot for 8 feet diameter.	Total Amounts.
	Estimated Quantities...		1565	770	644	380	380	380	Lineal Feet.
									Informal.
3	Jos. R. B——	0	$11.50	15.00	17.00	19.00	21.00	24.00	64,815.50
7	Jas. M. K——	.9	14.75	18.00	19.50	20.25	22.75	24.50	75,151.75
5	Jas. A——	8	10.50	11.50	24.00	27.00	27.00	28.00	71,903.50
8	P. & T. C——	6	14.80	14.80	19.70	23.75	25.00	27.00	76,029.80
12	Sam. O——	12	15.63	22.31	23.89	26.17	27.85	30.16	89,013.21
9	S. H. C——	6	13.75	17.71	19.58	22.00	23.81½	28.60	76,042.67
1	Hugh D——	12	5.00	12.00	15 00	20 00	30.00	30.00	57,125.00
2	B. F. D——	10	11.50	16.00	17.00	19.00	20.00	22.00	64,445.50
6	R. A. M——	9	13.00	16.50	18.25	21.25	24.25	28.50	72,923.00
4	E. D. S——	6	4.46	15.27	16.45	16.69	21.77	24 80	69,020.40
10	Jas. K——	18	14.50	14.70	24.00	24.72	26.00	27.68	79 259.50
11	P. H. McL. & B.E.	12	19 78	21.00	22.00	23.00	24.00	25.00	88,653.70

This table is computed by multiplying the quantity at the head of each column by the price bid in the same column, and adding these several products together for the total. For convenience in adding, it would be better to reverse the positions of the bidders and quantities, so as to bring the partial products in vertical columns, thus—

Method of calcu-ting results.

No. of Proposals......	3	3		7		Etc.	11
Names of Bidders.....		Jos. R. B.		Jas. M. K.		Etc.	P. H. McL and B. E.
Time.................		0		9		Etc.	12
	No. lineal ft.	Bids.	Par. prod.	Bids.	Par. prod.		
Price bid for 5½ feet...	1565	11·50	17,997·50*	14·75	23,083·75	Etc.	19·78
" " " 6 "...	770	15.00	11,550·00	18·00	13,860·00		21·00
Etc., Etc., ...	Etc.	Etc.	....	Etc .	....		.....
Total amounts.........			64,815·50		75,151·75		

* These products may be very rapidly obtained with absolute accuracy by the use of Grant's calculating machine.

An examination of the table shows a difference in the aggregates of nearly $32,000, and the highest bid is made out in odd cents, which is but an affectation of extreme accuracy where none exists. The figures were doubtless assumed without any reference to an estimate. Remarks on table.

There are also serious objections to the method of bidding by the lineal foot based on a certain estimated amount of material, as it is impossible to foresee what kind of foundations may be required, for in some cases piles and a grillage may be needed; in others, a bed of masonry, &c. This method of lineal measurement has recently been introduced in Philadelphia in consequence of difficulties in determining quantities for the Hart Creek Sewer, but the same objection still holds. The former method of estimating, based on the actual amount of each kind of work done, being the better; the following form is annexed as showing the manner of tabulating the results of bids made on that principle. Objections to estimating by lineal foot.

PROPOSALS RECEIVED AND OPENED. ....18..., AS APPROVED BY ORDINANCE..........18...

	No. of Proposal	....	1		2					
	Names of Bidders	Quantity	A. B. F. and J. S. P.		P. & J. S.		Etc.			
	Time in months	...	8		6					
		cub. yds	Bid.	Product.	Bid.	Product.	Bid.	Product.	Bid.	Product.
	Ordinary excavation									
	Rock excavation									
	Refilling & embankment									
	Brick masonry									
Stone Masonry.	Foundation									
	Regular coursed pitched ashlar									
	Random coursed pitched ashlar									
	Hammer dressed									
	Broken ashlar									
	Rubble									
	Dry walls									
	Coping (cub. ft.)									
	Arch and ring stones (cub. ft.)									
	Concrete									
	Piling (lin. ft.)									
	Foundation timber and planking (per M b m)									
	Manholes, per piece									
	Wellholes (lin. ft.)									
	Inlet Basin (piece)									
	Total amounts									

A similar form will answer for *any* kind of work.

If, as sometimes happens, two bidders have equal amounts, there are other considerations, such as quality of material, promptness of delivery, responsibility of bidders or sureties, etc., which will assist in determining to whom the contract should be awarded, or in some cases the award may be divided between them.

Two or more bids in equal amounts.

The proper person having been selected, official notice in writing should be served upon him to that effect, and the time within which to begin work *after his receiving the notice*, should also be specified.

Notice to be sent to successful bidder.

The accompanying extracts will explain the proceedings in opening bids for supplies of various kinds, and the manner of disposing of them.

PHILADELPHIA, APRIL 19th, 1876.

Meeting of the Water Committee of Councils.

The regular meeting of this committee took place yesterday afternoon, Mr. Shallcross presiding.

Bids were opened for excavating and filling the trench for the 20 and 30-inch mains, to connect the reservoir on the Wentz Farm with Ladner's Point, on the Delaware, and between the Wentz Farm and the Seven Stars Hotel. There were a large number of bids, the prices for excavation ranging from 15 cents per cubic yard for earth to 68 cents, varying with the depth, and for rock excavations from 60 cents to $3 per cubic yard.

Itemized bids were also received for building the foundations of the engine and boiler house and stack. All bids were laid over for one week, until a calculation can be made upon the several bids.

The contract for furnishing water pipe for the 48-inch mains for connecting the Spring Garden and Corinthian avenue basins was awarded to the Gloucester Iron Co., at 1.53 cents per pound.

Several ordinances for laying mains were reported favorably. Adjourned.

See page 214

WATER DEPARTMENT.

Meeting of the Council Committee—Bids Opened and Contracts Awarded.

The Water Committee of City Councils met at the headquarters of the Water Department, Thirteenth and Spring Garden streets, Mr. E. A. Shallcross in the chair.

Bids were opened for 250,000 pounds of pig lead for the use of the department, as follows: John Runkell and Joseph Solomon, at 8.85 cents per per pound, American; Tatham Bros.. 7.82 cents Spanish, and 7.48 Ameri-

can; Phelps, Dodge & Co., 7.50 for American, and 8·50 for Spanish; William H. Trotter, American, 7.45 cents.

Colonel Jones moved that the contract for all the lead required be awarded to William H. Trotter, when considerable discussion ensued, and finally the matter was postponed until the next meeting by a vote of 13 to 8, with the request that the Chief melt a little of Trotter's lead and see if it is good. This action made Dr. McFadden angry, and he said it would be impossible for him to do what he was requested. Proposals for furnishing 15,000 pounds of brass castings were then opened, as follows: Joseph L. Travis at 19¾ cents per pound, Spear and Richards 17 cents, and W. W. Keys 17 cents. A man named Welsh had the contract last year.

Mr. Hill moved that the contract be awarded to both parties, one half of the amount to each. This was not voted on, but the entire contract was awarded to Spear and Richards.

The following bids were then opened for 150,000 lbs. of iron castings:—Adams and Story, $2.24 per 100 lbs.; David S. Creswell, $2.37½; Jesse W. Starr & Son, $2.50; R. D. Wood & Co., $2.33⅛; Daniel Runkell, $3; Aaron Mellert, $2.12; Benjamin F. Archer, $2.75; and Todd & Jones, $2.12½. There were three proposals unaccompanied by a certificate from the City Solicitor.

A motion was made to award the contract to Todd & Jones, although they were half a cent higher than the lowest bidder. This led to some discussion. A motion to award it to the lowest bidder, Aaron Mellert, at $2.12 was agreed to.

Proposals for branches and sleeves were then opened as follows: Aaron Mellert, $2.45 per 100 pounds; Runkell, $3; O'Neall and Archer, $2,75; Gloucester Iron Works, $2.61; R. D. Wood & Co., $2.33⅓; Jesse W. Starr & Co., $2.50. The contract was awarded to R. D. Wood & Co.

Proposals for cast-iron pipes were then opened for 6, 8, 10, 12 and 48-inch pipes. The contract for the 6, 8, 10 and 12-inch pipes was awarded to Mr. Mellert at $1.42 for 100 lbs. he being the lowest bidder. The contract for the 48-inch pipes was awarded to R. D. Wood & Co., at $1.45 per 100 pounds.

A Meeting of the Committee of the Select and Common Councils

Was held Saturday Afternoon, April, 1871, at half-past three o'clock, in the Office of the Chief Engineer, Strickland Kneass, at the Department of Surveys, Fifth street, below Walnut. Present—Messers. W. S. Allen, Chairman; Robinson, Mitchell, Bickel, Smith and Cattell. Sealed proposals for the construction of a new bridge at the site of the present wire bridge at Fairmount having been received, were presented by Chief Engineer Kneas.

C. H. Latrobe, Esq., of Baltimore, submitted a proposal for the construction of the superstructure of the main bridge at the rate of $930 per linear foot. The Phœnix Iron Company submitted a proposal for the same work at $1125 per linear foot; also, for the Thirtieth street trusses, including

lateral bracing and exclusive of road formation above top cord $122 per linear foot; for removing suspension bridge, including towers, cables and roadway, $100; amount to be credited to the city upon contract materials in suspension bridge, including towers, cables and roadway, $100; wrought-iron work in approaches, 9 cents per pound, cast-iron 7 per pound.

Messrs. James F. Kennedy and John W. Murphy submitted the following proposals:

Excavation.

	Kennedy.	Murphy.
Earth per cubic yard,	.40	.40
Rock per cubic yard	$1.50	$1.48
In shafts, with curbing, per cubic yard	3.00	3.94
Removing masonry, old abutment, per cub. yard.	..	1.90
Removing timber platform per cubic ft	--	2.00
Removing piles, each	50.00	50.00
Embankment per cubic yard	--	.28

Masonry.

Foundations per perch of 25 cubic ft.	6.50	8.10
Retaining walls “ “	8.00	8.70
Old abutments (additions) “	11.00	9.50
Shaft with base for stone columns, cu. ft.	8.00	9.80
Pitched ashler per perch of 25 “	14.00	20.00
Drafted “ “ “ “	20.00	22.00
Piers for columns “ “ “	22.00	22.00
Belting courses per cubic foot	3.00	1.80
Cornice “ “	8.00	2.80
Stone pedestals “ “	6.55	3.50
Coping eight inches per square foot	2.40	1.50
Coping ten “ “ “	2.60	1.85
Coping thirteen “ “ “	2.85	1.95
Flagging inches “ “	.50	.50
Curbstone, twenty-six inches deep per lineal ft.	2.00	1.60
Curbstone, twelve “ “ “	1.40	1.00
Curbstone reset “ “ “	.20	.15
Stone block pavement per square yard	3.00	3.00
Cobble pavement, relaid, “ “	.40	.40
Wooden pavement “ “	4.00	3.50

Iron Work.

Wrought-iron per pound	--	.09
Cast-iron per pound	--	.05½
Cast-iron balustrade per lineal foot	--	9.80
Wrought-iron railing “ “	--	5.40
Cast-iron railing pedestals each	--	40.00
Cast-iron columns each	--	80.00

One globe lamp and stand, with connections, each	..	65.00
Three " " " " each	..	120.00
Main bridge superstructure....................	..	750.00
Thirtieth street trusses, &c..................	..	128.00
Pneumatic piling, including masonry...........	..	12,000.00
Removing old bridge...........................	..	4,500.00
Amount allowed to the city for materials of old bridge...............................	..	4,000.00

Chief Engineer Kneass announced that he would be prepared to report upon the proposals submitted at an early day. Also, that it was understood by the contractors that all proposals were exclusive of the work on the western approaches, which would be done, it was proposed, by the Pennsylvania Railroad Company for $47,000, at a clear saving of $67,000 to the city.

QUESTIONS ON THE FIFTH CHAPTER.

Page 219. Define genuine and straw bids. Who prepares the forms of bids and issues the instructions to bidders? How should proposals be endorsed and presented?

Page 220. Who are the guarantors? and how many are required in government contracts? Why is not the name of a firm sufficient? What is required concerning residence and prices? What amount is withheld from the monthly or periodical payments? and why? What forms shall be used for the contract? For what causes may bids be rejected?

Page 221. When will payments be made? Why are transfers of contracts prohibited? What security is required for the performance of the work? Why may bids not be received by telegraph? Why should the advertisement and specifications be attached to the bids? Why should bidders be present at the opening? State the law relating to the opening of bids.

Page 222. Why is the time for beginning work limited to ten days from the date of signing the contract?

Page 223 et seq. Prepare and fill up a form of proposal. Fill up a blank guaranty, a bond, and form for bondsman's oath.

Page 229 et seq. What are the requirements in bids for sewers? What is the form of proposal? How should it be filled up? What are the conditions of the bond?

Page 231 et seq. State the classification and method of arranging the items in bids for grading and masonry, as used on the P. R. R.

Page 233. Give the headings in the tabular form for tunnel proposals.

Page 234. What are the principal items in the bid for an iron bridge on the Easton & Amboy Railroad.

Page 235. When should the bids be opened? Describe the method of proceeding.

Page 236. State the form of table given for computing results of bids on sewers and its defects. What improvement is suggested?

Page 237. What criticisms are made on the bids? What are the objections to letting work of this kind by the lineal foot?

Page 238. What is to be done when two bids are equal? How are the successful parties to be notified?

Page 239 et seq. How are bids on the superstructure of bridges generally made?

The student should fill up bids for any piece of work which may be advertised in the daily papers.

CHAPTER VI.

THE CONTRACT.

Veritatis simplex, oratio est.

A contract (*con*, together, *traho*, to draw,) is an agreement to do a certain thing, such as performing work, furnishing supplies, or delivering materials, and is based upon a mutual understanding of the amount and nature of the work to be done by the contracting parties. That there may be no misconception concerning the intention of the parties, everything tending to throw light upon the subject-matter should be embodied in and form a part of the contract. Hence it is that the *advertisements*, *specification*, *drawings*, *proposals and agreements* all form essential parts thereof. They should be made out in duplicate, that each party may retain a copy, and if there be more than two parties, as sometimes occurs, each should be furnished a copy.

Definition.

Component parts.

Made out in duplicate.

There is practically no limit to the number of parties entering into a contract, although some authorities assert that there can be but two. There may be as many as there are interests involved in the proposed subject for agreement, as is instanced in the combination for mutual protection in the case of common carriers or transporters of merchandise or products.

Contracts are classified with reference to their form and objects into

Contracts or Agreements

Of Record, as in

- *Recognizances.*—An obligation of record entered into before some court of record or magistrate with conditions to do some particular act, as to appear at court, keep the peace or pay a debt. It differs from a *bond* in not requiring the seal of the party but merely his signature.
- *Judgments*—are decisions of a court requiring the performance of a specific act or payment of a sum of money.

Of Specialties, as in

- *Deeds or Indentures*—are sealed instruments in writing duly executed (signed and sealed) containing some bargain, &c., relating to real estate.
- *Bonds*—are sealed instruments binding the obliger to pay a certain sum of money before a certain date usually accompanied by the condition that if the obliger shall do the act agreed upon, the bond becomes void. Bonds are also entered into by sureties for faithful performance of duties of officers holding positions of trust.
- *Covenants*,—promises made under seal, but generally limited to a particular clause in a sealed instrument.

Simple or **Parole** include all not above enumerated, and may be verbal or written.

Express, as when stated in direct and formal terms.

Implied, as when derived from legal construction and when of such a nature that reason and justice demand their fulfilment.

A **stipulation** is an article or provision of a contract.

For a more complete exposition on these several heads, see the corresponding articles by Prof. T. W. Dwight, LL.D., in Johnson's New Cyclopœdia.

The *Four Essential Constituent Elements* of *all Contracts* are— The four elements.

1. That there shall be *appropriate parties.*

2. That there shall be *mutual consent* to the terms of the agreement.

3. That there shall be a *valid consideration*, actual or presumed.

4. And that there shall be a *definite subject-matter* to be acted on.

1.—The Parties.

The parties—two or more.

There must be at least two parties, either individuals or corporations, but there may be more. Those having something to be offered or done are designated as of the first part; those proposing to purchase or do the thing as the parties of the second part. All persons are capable of entering into contracts excepting those who lack sufficient age, as *infants*; or who may be of unsound mind, as *idiots or lunatics*; together with *married women, aliens, seamen, drunkards*, and in some instances, *bankrupts*. By *infancy*, at law, is meant a person under twenty-one years of age, although some States make an exception in favor of women at eighteen.

Of the first part.

Of the second part.

All persons may make contracts, except infants, idiots or lunatics, married women, aliens, seamen, drunkards and bankrupts.

Idiots and lunatics being presumed to be incapable of understanding the nature of an obligation, or its subject-matter, cannot, therefore, bind themselves in a contract.

But insane persons having lucid intervals may make agreements under seal at those times.

Drunkards.

A contract signed by a person who has been *intoxicated* by a drug or spirits to such an extent as to prevent reasonable action is void as having been obtained through FRAUD, before which nothing stands. So of a contract obtained through imposition upon weak minded persons.

Married women.

By marriage the legal rights of women are merged into those of their husbands, but in some States the laws are being relaxed in this respect.

Compulsory signatures.

Persons who are forced into contracts by duress, either through imprisonment or reasonable fear of injury to life or limb, are excused from their fulfilment.

Parties may make contracts on their own behalf or by duly authorized agents or representatives. Agents.

A corporation, however numerous its members may be, is regarded as a single individual, and it can generally only contract by deed under the corporate seal. Corporations.

2.—Mutual Consent.

There is no contract in law until the parties to it have agreed upon the same thing in the same sense. Agreement. Fraud annuls all obligation and all contracts into which it enters, and the law relieves the party defrauded, but the party acting fraudulently cannot set his own fraud aside for his own benefit.* Fraud.

An assent to a proposition is a simple and direct affirmative. If any condition be imposed by the party accepting, they must first be approved by the other party before a contract can be made. Assent.

If any offer be made on time for which a consideration is allowed, the party offering cannot withdraw before the expiration of that time, but if there be no consideration he may revoke it at any reasonable time *before* acceptance, but not after. Offers on time.

An offer made by letter holds good until a notice of its withdrawal reaches the party to whom it was made; and an acceptance is complete as soon as the letter containing it is mailed, whether received or not. A withdrawal may be made by telegraph to anticipate the letter containing the proposal, before it could have been received and accepted. By correspondence

3.—The Consideration.

The consideration gives to a contract a legal, as distinguished from a moral validity; for naked promises are not enforceable in law. The consideration is the cause, price or reason for the promise. It may be what is technically called good, as a natural affection, or it may be valuable pecuniarily, as in the payment of money, performance of work, forbearance to sue in certain cases, delivery of property, etc. Defined—good or valuable.

* Jeremiah xxii.: 13.

A legal consideration is necessary to the validity of every contract, and a seal upon a written instrument is regarded in law as an evidence of such consideration. The validity is not affected by the adequacy of the consideration, as that is a matter supposed to have been fully determined before the closing of the agreement.

Legal consideration necessary.

Adequacy of consideration does not affect validity.

If a consideration be illegal or impossible, as from sickness, etc., the contract founded upon it becomes nugatory.

Illegal or impossible considerations.

Or, should an apparently valuable and sufficient consideration become worthless before part performance on either side, the promise cannot be enforced, and money paid can be recovered.

If the consideration becomes worthless.

4.—*Subject Matter.*

Contracts may be made upon any subject with the exception of anything illegal or immoral. The subject must be some act agreed to be done, as some mechanical labor in the production of articles, some personal service rendered, or some property transferred.

May be anything not illegal or immoral.

It is understood that the parties contracting intend to do what is just and fair, and are not to be governed by the private intentions or mental reservations of either, but by the impressions produced upon one another by their mutual expressions, and as each must have understood the other.

Meaning must be clearly understood.

A perfect contract when made is in the nature of a private law, and binds the parties according to their intentions. Hence in case of dispute upon an oral agreement, the intention must be proved by evidence, but if the contract be in writing it proves itself and no evidence is admissible to vary the contract or affect its obligation. Evidence may be admitted, however, to prove the identity of the parties or of the things forming the subject-matter or to explain its meaning, and for this purpose experts may be admitted to testify.*

A perfect contract is a private Law.

If oral, evidence may be admitted to prove intention but not if written.

* Hence, in the case of Malone vs. the City of Philadelphia, for non-payment for work done and service rendered in constructing the Hart Creek Sewer, Judge Mitchell ruled out the testimony proposed by experts on the grounds that it was intended to dispute the amounts of the estimates approved by the Chief Engineer and Surveyor, and not to explain technicalities. As this is an important case and furnishes a good practical illustration of many legal points; some extracts from it will be found given at the end of this chapter.

"Generally speaking all written instruments are construed and interpreted by the law according to the simple, customary and natural meaning of the words used." Ordinary meaning of words.

If the wording be so obscure as to convey no idea of the intention, the instrument must be set aside. Obscure contracts null.

In determining the intention of the parties or the meanings of the words used, *custom* or *usage* * has great weight when it has been long established, and is not merely casual or is uniform and general, not personal and known to all the parties. But if the custom be illegal, unreasonable or oppressive, it will be inert, or it may be excluded by the express provisions of the contract even when well established.† Influence of custom or usage.

In addition to these four essential elements there are other conditions which will modify the terms of the agreement, such as the *time and manner of making payments*, *time of beginning and completing work*, *penalties for non performance*, *stipulations concerning extra work*, *provision for and precautions against accidents*, *&c.*, all of which will be more fully explained and illustrated in the following pages. Other conditions.

General Duties.

The general duties of each party should be stated separately. The contractor agrees to perform a certain piece of work which should be carefully described, and the employer to pay a certain reward in a specified manner and currency. Duties of the parties. The general stipulations concerning the contractor are 1st, that he shall *finish the work*; 2d, to exercise care and skill in its performance; 3d, that he shall complete it in a given time; 4th, to comply with particular stipulations as to the manner of performance, &c. These should all be clearly expressed by themselves and not confused with those of the other party. Those of the contractor.

The duties of the employer are 1st, to make the payments at the times agreed upon; 2d, to assist the contractor in the execution of his contract, and not impede Those of the employer.

* E. g: "A man agreed to pay a carpenter 12 shillings *a day* for all the men he employed on a certain building. The carpenter proved that by the *usage* of that trade "a day" meant ten hours work and as his men had worked twelve and a half he was permitted to charge fifteen shillings for 1¼ days for every day so spent."

† Parson's Laws of Business.

him nor throw obstacles in his way. For instance, when the employer agrees to provide the materials he should cause them to be delivered before required, that the contractor may not be unnecessarily delayed in the completion of his work.

Payments.

Payments may be made by instalments based on monthly estimates of work done, or they may be made at once on the completion and delivery of the work. In the former case it is customary to reserve a portion of the amount due, varying from 10 to 20 per centum, to insure completion.

Payments.

In the latter case, i. e. when the work is to be finished before payment, the risk of all accidents, either from fire, flood, or other agents, rests upon the contractor, but if there be no contract or custom requiring the work to be done before payment, the workman is entitled to pay for what he has done in the event of accident, fire, &c., provided it be not caused by his neglect of proper precautions.

Risk of accident rests upon contractor.

The contractor cannot claim a payment until the work has passed into the hands of his employer, but if the latter should decline to receive the work the contractor may bring an action to compel acceptance.

No payment before delivery.

Payments may also be made by instalments, based on a certain specified quantity of work. In such cases nothing can be claimed until all the work required to entitle the contractor to a payment has been done. Should he stop before reaching that point, nothing can be recovered, but otherwise he is entitled to be paid for his work as it proceeds.

Payments by instalment based on work done.

If the contractor be required to obtain the certificate of an Engineer, Architect, or Inspector as to the quality or quantity of the work, before payments are made, it must be done before he can claim a settlement.

Certificates must be obtained if required.

Payment of Penalties for Delays.

If the contract provide for the payment of a penalty for delay in completing work it is a debt from the contractor to the employer, and may be recovered by an action; but should the contractor be delayed by the employer in the commencement of the work

Penalty for non-performance a debt to employer.

If contractor be delayed by employer.

or during its progress, he is not responsible for not completing in time or for the penalty.

A breach of the contract by the employer which does not operate to prevent completion of work within the time specified, and which may be compensated in damages, does not excuse the contractor from performance or from the payment of the penalty for delay; neither is he excused if additional work is ordered for which extra time has been allowed.

A breach by employer.

Extra work.

Time.

When there is no time specified the work must be done within a reasonable period.

The limit of a fixed time is the last moment of the day named, that is twelve o'clock at night, and in estimating the time, the day from which it is counted should be excluded. When time is expressed in months, the calender months are intended, as six months from the 15th day of January would be until the midnight between the 15th and 16th of the July following.

Limit of time.

Calender months.

Limitations.

The Statute of Limitations differs in different states, but generally it enacts that all actions at law in simple cases, that is, those which do not rest on a seal or judgment, must be entered within six years from the time when they become due, and in the case of sealed instruments an action at law may be entered at any time before the expiration of twenty years.

Limitations.

For simple cases six years.

For sealed contracts twenty years.

Guaranty.

A guaranty is generally required of persons bidding for public works, but not usually in contracts with corporations or private parties.

Guaranty.

It is a special promise to be responsible for the payment of some debt or the performance of some obligation in case of the failure of another person who is primarily liable for such payment or performance. It requires all the elements necessary to give contracts validity.

Defined.

Its requirements.

Written Contracts.

The Statute of 2d June, 1862, relating to Government contracts in writing is as follows:

§ 3709. It shall be the duty of the Secretary of War, of the Secretary of the Navy, and of the Secretary of the Interior, to cause and require every contract made by them severally on behalf of the Government, or by their officers under them appointed to make such contracts, to be reduced to writing and signed by the contracting parties, with their names at the end thereof; a copy of which shall be filed by the officer making and signing the contract in the Returns Office of the Department of the Interior, as soon after the contract is made as possible, and within thirty (30) days, together with all bids, offers and proposals to him made by persons to obtain the same, and with a copy of any advertisement he may have published inviting bids, offers or proposals for the same. All the copies and papers in relation to each contract shall be attached together by a ribbon and seal, and marked by numbers in regular order, according to the number of the papers comprising the whole number.

25 July, 1868. § 3733. No contract shall be entered into for the erection, repair or finishing of any public building, or for any public improvement whatever, which shall bind the Government to pay a larger sum of money than the amount in the Treasury appropriated for the specific purpose. Appropriations required before making contracts.

The annexed forms are given to fully illustrate the preceding principles. The first is the general form as used by the Engineer Corps U. S. A. with its accompanying bond.

ARTICLES OF AGREEMENT entered into this..........day of.......... eighteen hundred and............(18 ,) between...................... ......, Corps of Engineers U. S. Army, for and in behalf of the United States of the first part, and.., partners, doing business under the firm-name of......................., of..............., in the county of.............., State of.............., of the second part:

This agreement witnesseth that the said parties have mutually agreed, and by these presents do mutually covenant and agree, to and with each other in the manner following, namely: That the said.................. ....shall, in conformity with the advertisement aud specifications hereunto attached, and which form a part of this contract,...

....

....

....

....

....

That all materials furnished and work done under this contract shall, before being accepted, be subject to a rigid inspection by an inspector appointed on the part of the Government, and such as....... not conform to the specifications set forth in this contract shall be rejected. The decision of the engineer officer in charge as to quality and quantity shall be final.

That the said... shall commence..................... on or before the..................... day of........, eighteen hundred and........, (18 ,) and shall complete the..................... on or before the........ day of........, eighteen hundred and........(18 .)

That payment shall be made when the.............. contracted for shall have been delivered and accepted, reserving........ per centum from each payment until the whole........ shall have been so delivered and accepted.

And it is also agreed that if, in any event, the party of the second part shall delay or fail to commence with the delivery of the material or the performance of the work at the day specified herein, or shall, in the judgment of the engineer in charge, fail to prosecute faithfully and diligently the work in accordance with the specifications and requirements of this contract, then, in either case, the party of the first part, or his successor legally appointed, shall have power, with the sanction of the Chief of Engineers, to annul this contract by giving notice in writing to that effect to the party (or parties, or either of them) of the second part; and, upon the giving of such notice, all money or reserved percentage due or to become due to the party or parties of the second part by reason of this contract shall be and become forfeited to the United States; and the party of the first part shall be thereupon authorized, if an immediate performance of the work or delivery of the materials be in his opinion required by the public exigency, to proceed to provide for the same by open purchase or contract, as prescribed in section 3709 of the Revised Statutes of the United States: Provided, however, that if the party (or parties) of the second part shall by freshets, ice, or other force or violence of the elements, and by no fault of his or their own, be prevented either from commencing or completing the work, or delivering the materials at the time agreed upon in this contract, such additional time may, in writing, be allowed him or them for such commencement or completion as, in the judgment of the party of the first part, or his successor, shall be just and reasonable; but such allowance and extension shall in no manner affect the rights or obligations of the parties under this contract, but the same shall subsist, take effect, and be enforceable precisely as if the new date for such commencement or completion had been the date originally herein agreed upon.

And it is further expressly understood and agreed that no claim whatever shall at any time be made upon the United States by the party or parties of the second part, for or on account of any extra work or material performed or furnished, or alleged to have been performed or furnished, under or by virtue of this contract, and not expressly bargained for and specifically in-

cluded therein, unless such extra work or materials shall have been expressly required in writing by the party of the first part or his successor, the prices and quantities thereof having been first agreed upon by the contracting parties, and approved by the Chief of Engineers.

And it is also further agreed by the parties of the second part, as required by the 14th section of the act of Congress approved July 17, 1862, that neither this contract nor any interest therein shall be transferred to any other party or parties, and that any such transfer shall cause the annulment of the contract as far as the United States are concerned.

No member of Congress, officer or agent of the Government, or any person employed in the public service, shall be admitted to any share herein, or any benefit which may arise herefrom.

In witness whereof the undersigned have hereunto placed their hands and seals the day and date first above written.

(Executed in quintuplicate.)

Witnesses:

-------------------------- --------------------------[L. S.]*

-------------------------- --------------------------[L. S.]

I do solemnly swear that the copy of contract hereto annexed is an exact copy of a contract made by me personally with--------------------------; that I made the same fairly, without any benefit or advantage corruptly to the said------------------------------or any other person; and that the papers accompanying include all those relating to the said contract as required by statute in such case made and provided.

-----------------------------,

---------------of Engineers.

Subscribed and sworn to before me this--------day of---------

-----------------------.

Bond.

Know all men by these presents, That we,--------------------------- ------------------------------are held and firmly bound to the United States of America in the sum of----------------------------------lawful money of the United States; for which payment, well and truly to be made, we bind ourselves and each of us, our and each of our heirs, executors, and administrators, for and in the whole, jointly and severally, firmly by these presents.

Sealed with our seals, dated the-----------day of-----------in the year of our Lord eighteen hundred and seventy-------(187 .)

The condition of this obligation is such, that whereas certain articles of agreement, bearing date the-----------day of-----------, 187 , have been entered into by and between---------------------, Corps of Engineers, U. S. Army, acting for and in behalf of the said United States, and the above

* L. S. *Locus Sigili*, the place of the seal.

bounden.., for ...., at.................. Now if the above bounden.................................shall, for and during the period during which the said articles of agreement shall, by their original terms, as well as by reason of any extension of time which, as provided in said articles, may be granted for their performance, continue in force, duly and fully observe, comply with, and perform all and singular the terms, conditions, covenants, and agreements which, on the part of the said...... ...., are in said articles of agreement covenanted and agreed to be observed, complied with, and performed, then this obligation shall be void; otherwise, shall remain in full force and virtue.

In presence of us:

....	........................*
....	........................*
....	........................*

U. S. Light-House Board.

Contract.

See pages 77, 211, 227.

Articles of Agreement, made and entered into between........... ...., of the county of................... and State of.........................of the first part, and ....acting for and in behalf of the United States of America, of the second part, witnesseth:

Parties.

That the part of the first part, in consideration of the matters hereinafter referred to and set out, and of the specifications attached hereto, and forming a part of this contract, covenant and agree , to and with the party of the second part, to furnish all the materials and labor necessary to completely construct, erect at the workshop, take down after acceptance, and deliver (except the woodwork, the glass for the lantern, the lens, lamps, and other furniture belonging thereto), on board vessel at the port of..... ...., on or before the...... ....day of..............., anno Domini one thousand eight hundred and seventy-........., the metal work for the superstructure for a light house for Southwest Ledge, Long

Terms or conditions for party of first part.

Place and time of delivering materials

* Must be sealed with wax or other adhesive substance.

Island Sound, and that the said..
..............................shall commence.......... Time of beginning work.
....
on or before the.............day of.................., eighteen hundred and............., (18).

And the said part of the first part further agree to forfeit the sum of twenty dollars per day, as liquidated damages, for each and every day's delay in completing the work after the said date, said amount to be deducted from any sum due the said part of the first part in the hands of the Light-House Establishment, and to conform in every particular to the stipulations and conditions specified in this contract, and to the specifications and drawings hereto annexed, and which are to be considered as a part of this contract.

Liquidated damages.

Specifications to form part of contract.

The part of the first part agree to be governed in all matters regarding the work by the party of the second part, or the authorized agent thereof; and that every portion of said work shall be subjected to a rigid inspection by the party of the second part, or his agents appointed therefor, and that this inspection shall be final.

Inspection and approval.

And the party of the second part covenants and agrees to pay the part of the first part, as full consideration and price of and for said light-house.........................
....
....
upon receiving satisfactory evidence that the work has been completed and delivered in accordance with the terms of this contract, and to the satisfaction of the authorized agent of the party of the second part:

Party of second part.

Consideration and payment.

upon evidence.

Provided, however, that in case the party of the second part shall at any time be of opinion that this contract is not duly complied with by the part of the first part, or that it is not in due progress of execution, or that the said part of the first part.............irregular or negligent, in such case he, the said party of the second part shall be authorized to declare this contract forfeited, and thereupon the same shall become null, and the part of the first part shall have no appeal from the opinion and decision aforesaid; and the right to except to or question the same, in any place or under any circumstances whatever, is hereby released by the part of the first part; but the part of the first part shall remain liable to the party of the second part for the damages occasioned to him by the said non-compliance, irregularity, or negligence, and that all money or reserved percentage that may be due by virtue of the provisions of this contract will be forfeited to the party of the second part.

For failure to comply with conditions work may be suspended ond party of first part pay damages.

And it is further stipulated and agreed that no member of Congress shall be admitted to any share or part of this contract or agreement, or to any benefit to arise therefrom; and this contract shall be in all its parts subject to the terms and requisitions of

Improper influence in securing contracts or appropriations for works.

an act of Congress passed on the twenty-first day of April, in the year of our Lord one thousand eight hundred and eight, entitled "An Act concerning public contracts."

Law limiting amonnt of contracts to appropriations.

And this contract is also expressly understood to be subject to the terms and conditions of the joint resolution of Congress approved April fourteenth, one thousand eight hundred and fifty-two, containing a proviso in the following terms, viz: "Provided nothing herein contained shall be so construed as to authorize any officer or agent of the United States to bind the United States by contract beyond the amount appropriated by Congress, or to sanction any such contract heretofore made."

Excluding employers and U. S. officials under penalty

And it is further covenanted and agreed, that no person connected with, or engaged in the Light-House Establishment service shall be allowed to contract for labor or materials, nor to be interested in this contract, nor to any benefit to arise therefrom; and for any violation of this covenant and agreement the part   of the first part shall forfeit all moneys which may become due........................under this contract.

Not to be sub-let nor assigned.

Provided, also, that it is expressly understood and agreed that this contract shall not be sub-let nor assigned; but that it shall be well and truly carried out and fulfilled in good faith by the above recited part   of the first part, and that payment on account thereof shall be made to the aforesaid part   of the first part,   heirs, executors, or administrators, or to such person or persons as   may lawfully authorize, by power of attorney, to receive the same.

Payments to be well and truly made.

Contract subject to the approval of Lt. House Board.

And provided further, that this contract shall not be binding upon the United States until it shall have been approved by the Light House Board.

Mutual consent.

And for the true and faithful performance of all and singular the covenants, articles and agreements hereinbefore particularly set forth, the subscribers hereunto bind themselves, jointly and severally, their and each of their successors, heirs, executors, and administrators.

Bondsmen's Oaths.

STATE OF.........................., } *ss.*
County of.........................., }

........................., being duly sworn, deposes and says that he resides at No......,.......street, in the............of........... in the State of............; and that the value of his property, over and above all debts and liabilities incurred by him, is over..................dollars, ($......,) and that he is fully responsible for the amount of his obligation in the foregoing bond by him executed.

....

Sworn and subscribed this........day of.........., 187 , before me.

......................[L. S.]

....

STATE OF......................., } ss:
County of..................., }

..........................., being duly sworn, deposes and says that he resides at No..................street, in the...........of...........in the State of...............; and that the value of his property, over and above all debts and liabilities incurred by him, is over.................. dollars, ($........,) and that he is fully responsible for the amount of his obligation in the foregoing bond by him executed.

....

Sworn and subscribed this........day of........, 187 , before me.

....................,[L. S.]

....

Certificate of Solvency.

I certify that I have made due and diligent personal inquiry as to the ability of the signers of the foregoing bond, and am satisfied that they are good and sufficient, and fully responsible for the sum of..................... ....dollars, ($......) each.

....

....

Date:.....................

NOTES.—The sureties' certificate of solvency must be signed by an officer of the Government known to the Treasury Department.

Each surety will qualify in double the amount of the bond.

Form of Bond with Contract.

Know all men by these presents that we, ...

...................., citizens of..................State of.......... are held and firmly bound unto the United States of America in the sum of ....dollars, ($..........), lawful money of the said United States of America, as liquidated damages, to be paid to the United States of America or its authorized agent; for which payment well and truly to be made, we, and each of us, do bind ourselves, and each of our heirs, executors, and administrators, jointly and severally, firmly by these presents.

Sealed with our seals, and dated this ....day of..............anno Domini one thousand eight hundred and seventy-....

Whereas the above bounden...................................... by an instrument in writing, under....hand and seal , dated the....... of.........., contracted with the United States of America to construct and deliver the metal work for the superstructure of the light-house for Southwest Ledge, Long Island Sound, on the conditions and for the considerations in the annexed and preceding contract, according to the specifications contained in or annexed to said contract and the plans alluded or referred to in the same:

Now, therefore, the condition of the above obligation is such, that if the said...

shall well and truly, and in good, sufficient, and workmanlike manner, furnish and deliver the said light-house mentioned in the aforesaid contract, and complete the same in accordance with the terms and provisions therein stipulated, and in each and every respect fully comply with the conditions therein contained, then this obligation to be void; otherwise, to remain in full force and virtue.

Signed and sealed in the presence of—

Witnesses:

....[L. S.]
....[L. S.]
....[L. S.]
....[L. S.]

NOTES.—All the sighatures of bidders, contractor and sureties chould have affixed to them seals of wax or wafer, and their first names should be written in full,

The residence of sureties and witnesses should be given.

The bondsmen must qualify in the forms following.

Thus covenanted, made, and agreed by the parties this Date. ......day of........anno Domini one thousand eight hundred and seventy-..... , as witness their hands and seals.

....................[Seal.] Signature of parties under seal.
....................[Seal.]
....................[Seal.]
....................[Seal.]
....................[Seal.]

Signed, sealed, and delivered in presence of—

Witnesses:

.... Witnesses.

....

Forms used for Municipal Work.

CONTRACT

FOR THE CONSTRUCTION OF THE SNYDER AVENUE MAIN SEWER, ON SNYDER AVENUE, FROM SIXTH STREET TO THE DELAWARE RIVER.

CITY OF PHILADELPHIA.

THIS AGREEMENT, made this *twelfth* day of *July*, in the year of our Lord one thousand eight hundred and seventy-*seven*, between "The City of Philadelphia," hereinafter called the party of the first part, and *Hugh Deehan, of the City of Philadelphia*, hereinafter called the party of the second part,

WITNESSETH, That the party of the second part, for and in consideration of the payments hereinafter specified and agreed to be made by the party of the first part, hereby covenants and agrees to furnish and deliver all the materials and to do and perform all the work and labor required to be furnished and delivered, done and performed in and about the construction of a certain Main Sewer *on the line of Snyder Avenue, from Sixth Street to the Delaware River, in the City of Philadelphia*, as authorized by Ordinance, approved, in strict and entire conformity with the plans on file at the Survey Department, and in strict and entire conformity with the Specifications, a copy of which is hereto annexed, and which said plans and specifications are hereby made part of this agreement, as fully and with the same effect as if the same had been set forth at length in the body of this agreement.

The party of the second part further covenants and agrees that all of said materials shall be of the best of their several kinds and qualities, and that all of said work and labor shall be done and performed in the best and most workmanlike manner: and that all of said materials and work and labor shall be subject to the inspection and approval of the Chief Engineer and Surveyor of the City of Philadelphia, or his duly authorized assistant, and in case any of said materials or work shall be rejected by the said Chief Engineer and Surveyor or his assistant, as defective or unsuitable, then the said materials shall be removed and replaced with other materials, and the said work shall be taken down and done anew to the satisfaction and approval of the said Chief Engineer and Surveyor or his assistant, at the cost and expense of the party of the second part.

The party of the second part further covenants and agrees that all of said materials shall be furnished and delivered, and all of said work and labor shall be done and performed to the satisfaction and approval of the said Chief Engineer and Surveyor, on or before the expiration of *twelve* months from the date of notice to commence work under this contract, and if for any reason, except for the written consent of the said Chief Engineer and Sur-

veyor, as hereinafter provided, the completion of the said work shall be delayed beyond that date, then the party of the second part shall pay to the party of the first part, as liquidated damages and not as a penalty, the sum of Twenty Dollars per day for each and every day during which the said work shall be so delayed. But the said Chief Engineer and Surveyor, upon written notice from the party of the second part, of the existence of causes over which he has no control, which must delay the completion of the said work, may extend the period of its completion, and in such cases the damages for delay shall begin to run from the period to which the date of completion shall have been so extended.

And it is further expressly understood and agreed by and between the parties hereto, and it is hereby made part of this agreement, that if in the opinion of the said Chief Engineer and Surveyor the party of the second part shall be prosecuting the said work with an insufficient force of workmen, or with an insufficient stock of materials for the prompt completion of the said work, or shall be improperly performing the said work, or shall discontinue the performance of said work before completion, or shall neglect or refuse to remove such materials or to take down and rebuild such work as shall be rejected by the said Chief Engineer and Surveyor as defective or unsuitable, then in any such case, it shall be lawful for the said Chief Engineer and Surveyor, and he is hereby authorized and empowered to purchase such materials and to employ such contractors or workmen as in his opinion shall be required for the proper completion of the said work, at the cost and expense of the party of the second part.

And the party of the second part further covenants and agrees properly to enclose the said work and to place signal lights thereon all night, and to be responsible for and pay all loss or damage which may in any manner arise by reason of the construction of the said work, during the progress of the same.

The party of the second part further covenants and agrees not to assign, transfer or sub-let this contract. It is further expressly understood and agreed by and between the parties hereto, and it is hereby made part of this agreement, that nothing contained in this contract or in the specifications hereto attached, shall be taken or construed to preclude the party of the first part from contesting the estimates or certificates of the Chief Engineer or other Officer, or the claim of the party of the second part under this contract, or under such estimate or certificate, but the party of the first part shall be at full liberty to take every legal defense to the character, quality and quantity of the said work and materials, and to the time and manner in which the same shall be furnished and done, notwithstanding the certificates or approval of the said Chief Engineer or other Officer.*

In consideration of the premises, the party of the first part hereby agrees

* This clause has recently been introduced and forms an important element in all such cases. It is not always wise to vest too much absolute authority in the hands of one man, leaving no redress in case of errors or misunderstandings which do frequently arise.

to pay to the party of the second part the following prices as full compensation for furnishing all the material and labor in building and constructing, and in all respects completing the aforesaid work and appurtenances, in the manner before specified, to wit:

For furnishing the materials and building the sewer and appurtenances, according to the plans and specifications, and including all the excavation, whether rock, earth, quicksand, caves, or otherwise; also all piles driven to such depths as may be ordered to render the work secure; also all timber and plank used for sheet-piling, foundations and for supporting the banks or sides of the excavation; also all embankment for foundation or covering or elsewhere; also the filling in of the earth around and over the sewer and appurtenances to the height which previously existed, unless otherwise directed; also the repairs to the water-pipes and gas-pipes; the removal and disposal of all rock, rubbish, or surplus earth dug out of the trenches, the taking up and removing the paving stones, and the earth and sand from the trenches, to such part of the street or vicinity as may be directed by the Engineer; also all the relaying of curb, gutters, flag and paving stones, rendered necessary by the construction of the work; also the furnishing of earth or sand for refilling the trenches, in case of deficiency; also the preparation of the bottom, where rock has been blasted out; also all pumping and bailing rendered necessary by the character of the work; also the cleaning out of the sewer and drains, and the removal of all rubbish immediately after the completion of each section; also all loss or damage to person or property, arising out of the nature of the work aforesaid or its prosecution, or from the action of the elements, or from any unforeseen obstructions or difficulties which may be encountered in the prosecution of the same; including also the furnishing of all necessary materials and labor, and the performance of the whole of the work mentioned in the specifications, and also all expenses incurred by or in consequence of the suspension or discontinuance of said work as before specified, or of a faithful compliance with each and every of the requirements of this agreement, and for well and faithfully completing the same, and the whole thereof, in the manner elsewhere specified, to wit: provided the amount to be paid under this contract shall not exceed in the aggregate the sum of fifty-seven thousand one hundred and twenty-five dollars.

For	sewer	5½	feet in	diameter,	per lineal	foot,	five dollars, ...	$ 5.00
"	"	6	"	"	"	"	twelve dollars........	12.00
"	"	6½	"	"	"	"	fifteen dollars........	15.00
"	"	7	"	"	"	"	twenty dollars.......	20.00
"	"	7½	"	"	"	"	thirty dollars........	30.00
"		8	"	"	"	"	thirty dollars........	30.00

Payment therefor to be made in monthly instalments, upon certificates furnished by the Chief Engineer and Surveyor aforesaid, of the amount of work satisfactorily executed during each month, less twenty per cent. to be retained until the completion and acceptance of the said work. The said

payments to be made in assessment bills, prepared as specified in Section Two of Ordinance "Regulating the Assessment upon Property, for the Construction of Sewers," Approved May 12th, 1866, and Warrants upon upon the City Treasurer, payable in bonds or cash, at the discretion of the Mayor. All of which payments shall be received as so much cash, and be collected without recourse to the City of Philadelphia; but for the purpose of the better enabling them to collect the same, the name of the said City may be used, and all her legal remedies, whether by bill or otherwise employed. The final payment to be made in full settlement one month after the date of the satisfactory completion of the said work.

In witness whereof the Corporate seal of the party of the first part, attested by the Mayor of the said City, hath been hereto affixed, and the party of the second part hath hereto set his hand and seal, the day and year first above written. (Signed)

Sealed and delivered in the presence of (Signed) W. N. ASHMAN.

THOS. DEEHAN, [L. S.]
W. S. STOKLEY, [Seal.]

See page 104.

CONTRACT

FOR COMPLETION OF COOL SPRING RESERVOIR, WILMINGTON, DEL.

THIS AGREEMENT made this *Seventeenth day of July*, one thousand eight hundred and *seventy-seven*, between *P. F. C* *and J. K* , *of the City of Philadelphia*, State of *Pennsylvania*, of the first part, and *John P. Allmond, James Bradford and Cæsar A. Rodney*, Water Commissioners of the City of Wilmington, State of Delaware, of the second part.

(The above mentioned Commissioners were appointed by act of the General Assembly of the State of Delaware, passed at Dover on the twentieth day of March, One Thousand Eight hundred and Seventy-Seven.)

Witnesseth, that the said *P. F. C* *and J. K* , in consideration of the covenants of the said Commissioners, hereinafter contained, do covenant and agree to and with the said Commissioners to complete the North Basin of the Cool Spring Reservoir in the time and manner as required by the attached printed Specifications (see page 104) and in accordance with the plans and directions of the Engineer in charge of the said work; also to complete the South Basin of said Reservoir at such time as may hereafter be fixed by said Commissioners and under the conditions of section first of the attached specifications.

And the said Commissioners do covenant and agree to pay to the said *C* *& K* , the sum of Thirty-three thousand dollars ($33,000) at the times and in the manner specified in article thirty-four (34) of the attached specifications, for the material and labor required to complete the

North Basin of the said Reservoir, and also to pay the said *C* *&* *K* at the times and in the manner specified in Article Thirty-four (34) of the attached specifications, the sum of Thirty-six thousand dollars (36,000) subject to the conditions of Article First of said specifications for the labor and material required to complete the South Basin of said Reservoir.

And it is mutually agreed by both parties to this contract that they shall be governed in all things relating to the work at Cool Spring Reservoir by the attached printed specifications or by such alterations or modifications of the same as shall hereafter be agreed upon by said parties.

In witness whereof we have hereunto set our hands and seals this seventeenth day of July, one thousand eight hundred and seventy-seven.

Signed,
J. P. A , (seal)
JAS. B , (seal)
C. A. R , (seal)
Water Commissioners.

Witnesses:
JOB. H. J ,
WM. F ,

P. F. C , (seal)
J. K , (seal)
Contractors.

Boston Aqueduct.

Contract for Iron Pipe.

Articles of agreement, made and concluded the day of in the year eighteen hundred and forty-seven, between

of the one part, and the Water Commissioners of the City of Boston, of the other part, whereby it is covenanted and agreed as follows, to wit: the said

hereby covenant and agree that will construct, furnish and deliver, in a good and sound condition, agreeable to the specifications hereinafter contained, on some wharf in the City of Boston, as may be designated by said Commissioners, a quantity of cast iron water pipes, as follows, to wit:

including such variety of branch, curve, bevel hub, double hub, hydrant bends, taper pipes, sleeve pieces, and such other pieces for connecting with

those above designated, as may be required by the said commissioners. It is understood that the diameter of pipes refers to the interior diameter.

The pipes to be constructed so as to form, in laying down, the connection designated as the faucet and spigot joint. The dimensions and form of the hub, or socket end, and also the bead on the spigot end, are to be made in conformity with the plan submitted by the Chief Engineer, in the employ of the Water Commissioners. Kind of joint.

The single hub pipes, including taper pipes and curved pipes, with the ordinary straight pipes, are to be made in lengths of 9 feet, including the hub or socket. The double hub pipes are to be in lengths or pieces of 4 feet. The branch pieces are to have such length as will allow the joints to be conveniently made, beyond the curvatures of the several branches. Length of pieces.

The sleeve pieces will vary in dimensions, so as to suit the different-sized pipes, according to the drawing of the aforesaid engineer.

The thickness of metal to be, for 30-inch pipes, 1 inch; for 24-inch pipes, ⅞; for 20 and 16-inch pipes, ¾; for 12, 6 and 4-inch ½ of an inch. Thickness of metal.

The pipes to be made from pig iron, of a quality to make a sound and strong casting, and such as will bear drilling and filing, and be cast from a cupola or air furnace. All straight pipes to be cast in a vertical position with the hub end down, and all other pipes to be cast in the same position, so far as their form will permit. Character of casting

Care shall be taken to guard against the pipes falling short of the specified diameter in the inside, and that they do not exceed the specified diameter more than 3-16 of an inch, for 16-inch pipes, and a proportionate excess for pipes of intermediate and smaller sizes; and that in all cases they have such uniformity in diameter as will not impair the facility of making the lead joint; and to guard against inconvenience in assorting the pipes, the said contractor agree to put a conspicuous mark on each end of each piece of pipe that exceeds the exact diameter, by which the varying diameters may be designated and known, to wit: those that exceed the exact diameter by the least amount, are to be designated as No. 1. Those that exceed the exact diameter by the next largest amount, as No. 2. And those that exceed the exact diameter by the largest amount, as No. 3. Uniformity in diameter.

The pipes shall be uniform in the thickness of metal, as specified for the several different sizes or diameters, and care taken that they shall not be less than the specified thickness, nor exceed the same, more than will produce an extra weight, or a deficiency of weight of one hundred pounds per piece of 30-inch pipe, eighty pounds per piece of 24-inch pipe, seventy pounds per piece of 20-inch pipe, fifty-five pounds per piece of 16-inch pipe, forty pounds per piece of 12-inch pipe, twenty pounds per piece of 6-inch pipe, and ten pounds per piece of 4-inch pipe, over a strict calculation of the contents specified, which is to be computed at the rate Thickness of metal, uniform.

of twenty-seven hundredths of a pound to one cubic inch of metal. And pipes not conforming to this specification shall be rejected.

By uniformity of thickness is understood that the pipes shall not vary from the specified thickness more than 1-16 of an inch on either side. This uniformity, and also the quality of the metal, shall be tested, in any manner the said engineer shall deem satisfactory.

After delivery on the wharf, as before provided, the 30, 24 and 20-inch pipes are to be subjected to a proof of two hundred and fifty pounds pressure per square ineh; and all other pipes to a pressure of three hundred pounds per square inch. The pipes to be inspected and proved by, and under the direction of, the aforesaid engineer, and at the expense of the aforesaid commissioners. If any pipes are increased in thickness of metal, a corresponding increase of pressure in the proof will be applied. Proof.

The pipes, branches and other pieces, to be furnished in such order, in regard to the different kinds, as may be required by the aforesaid engineer, who will give bills specifying the order for delivery. Ordet of delivery.

The time of delivery to be as follows, to wit:

Tons.
"
"
"
"
"
"
"

The said commissioners may increase the quantity of pipes, beyond what is herein provided for, to any extent, not exceeding 10 per cent. of the specified amount, provided notice is given the Contractor of their decision to require it, at least three months before the time for the last delivery. Quantity may be increased.

In this contract a ton weight is understood to mean a gross ton, or to contain 2,240 pounds. Ton Weight.

And the said Commissioners do hereby engage that, whenever in the opinion of the said Chief Engineer, this contract shall be wholly completed on the part of the said contractor , they will pay for said work as follows:

For straight and taper pipe,

For curved and branch pipe.

The prices above specified to be in full compensation, and to include every charge for materials, workmanship and safe delivery, as provided in this contract.

During the prosecution of this contract, the said Commissioners agree to pay, on the certificate of said Engineer, as the pipe are delivered in accordance with the terms and provisions of this contract, as follows:—That on the delivery of a lot or parcel, as herein provided, the Monthly estimates

said Chief Engineer shall proceed to move the pipes to the yard or press prepared for the same, and after duly inspecting them and submitting them to the proof as herein provided, the said Engineer shall give a certificate of estimate for so much of said delivery as he shall find to meet the requirements of this contract; and the said Commissioners will pay to the said contractor within 10 per cent. of the contract price, for the pipe included in said estimate. It being fully provided and expressly understood that the said estimate will not be made oftener than once per month.

For a more full explanation of the form of the several pieces and parts, and the manner of providing for joints in all the details, the said Engineer will furnish plans or drawings of the several kinds of pipes herein provided, and give such directions from time to time as may appear to him necessary and proper, in order to make the work complete and perfect on the plan contemplated by this contract; and also bills specifying the number of pieces wanted of each; and the said plans, directions, and bills shall in every respect be complied with.

Inspection.

To prevent all disputes, it is hereby mutually agreed that the said Engineer shall in all cases determine the weight of the pipes delivered under this contract, and inspect and prove the same; and also that the said Engineer shall, in all cases, decide every question that can or may arise relating to the execution of this contract, on the part of the said contractor , and his estimate and decision shall be final and conclusive.

Final certificate.

It is further agreed that whenever this contract, in the opinion of the aforesaid Chief Engineer, shall be completely performed on the part of the said contractor , the said Engineer shall certify the same in writing under his hand; together with his estimate of the amount of the same, according to the terms of the contract; and the said Commissioners shall, within thirty days after the receipt of such certificate, pay the said contractor , the sum or balance, which according to this contract shall be due.

And it is further agreed that if, in the opinion of said Engineer, the contractor shall neglect or refuse to prosecute the work embraced in this contract, or perform the work in an improper manner, the said Engineer may certify the same in writing, to the said Commissioners, and in such case the said Commissioners shall have power to certify and declare that this contract has been violated and abandoned by the said contractor , and on making such certificate the said contract shall be deemed abandoned, and the said Commissioners may proceed to contract for the work with any other person.

It is hereby understood and agreed, that payment for the work herein contracted for shall be made in current bank notes of the city of Boston.

And it is further agreed by the parties to this contract, that in the case of the absence or inability to act of the said Chief Engineer, then and in that case, the Principal Assistant Engineer, in the employment of the said

Commissioners shall have, and is hereby invested with all the powers hereinbefore given to the said Chief Engineer in the premises.

Signed, Sealed and Delivered in presence of

See page 110.

ARTICLES OF AGREEMENT BETWEEN THE TRUSTEES OF THE UNIVERSITY OF PENNSYLVANIA AND MESSRS. STRUTHERS & SONS.

ATICLES OF AGREEMENT made and entered into the day of March, in the year of our Lord one thousand eight hundred and seventy-one (1871), between the Trustees of the University of Pennsylvania, of the first part, William Struthers, John Struthers, and William Struthers, Jr., all of the city of Philadelphia, copartners as contractors and builders, under the firm of Struthers & Sons, of the second part.

The said William Struthers, John Struthers, and William Struthers, Jr., copartners as aforesaid, for themselves jointly and severally, and for their respective executors and administrators, and for every of them do, and each of them doth hereby covenant and promise, and agree to and with the said The Trustees of the University of Pennsylvania, and their successors in manner following; that is to say, that they, the said William Struthers, John Struthers, and William Struthers, Jr., copartners as aforesaid, their several executors and administrators, for and in consideration of the sum of two hundred and thirty-one thousand nine dollars, to be paid to them by the said parties of the first part, at the times and in the proportions hereinafter set forth, shall and will at their own proper costs and expense for all material, carriage, labor, machines, insurance, and other charges, before the first day of August, in the year of our Lord one thousand eight hundred and seventy-two, with the best materials of the kinds specified and suitable for the proper purpose, substantially and in true workmanlike manner, to the entire satisfaction and under the supervision of Thomas W. Richards, the Architect appointed by said parties of the first part, and also with the approval of the Building Committee of the said The Trustees of the University of Pennsylvania, erect, build, set up, and finish according to the true intent and meaning of, and conformably in every respect with the plans, elevations, sections, drawings, and dimensions hereby adopted, and the specifications hereunto annexed, a Building with its appurtenances for the use and accommodation of the said The Trustees of the University of Pennsylvania and their successors, on the lot of ground bounded by Thirty-fourth and Thirty-sixth streets, and by Locust and Spruce streets in the city of Philadelphia, and upon the site therein designated by the said Architect and Building Committee—it being hereby agreed and covenanted by and between the said parties of the first and second part that the speci-

fications severally signed by the respective parties, and hereunto annexed before the execution of these presents, together with the plans and drawings by attestation of the said parties bearing even date herewith, shall be as valid and as binding to all intents and purposes as if in these Articles particularly set forth or incorporated: and further, that the decision of the said Thomas W. Richards, the architect aforesaid, shall be final and conclusive in any dispute which may arise by and between the parties hereto relative to the true purport and meaning of the plans and drawings hereby adopted, and of the specifications hereunto annexed; and it is hereby covenanted and agreed, and distinctly understood by and between the parties to this Agreement, that the said William Struthers, John Struthers, and William Struthers, Jr., copartners as aforesaid, shall not let or transfer this contract for erecting the said Building to any other person or persons, but will severally give their supervision to its complete performance; and it is hereby further covenanted and agreed by and between the said parties hereto, that upon notice from the Architect aforesaid, or from the Building Committee of the said parties of the first part, the said William Struthers, John Struthers, and William Struthers, Jr., copartners as aforesaid, their respective executors or administrators, shall and will take down, change, alter and reconstruct at their own proper cost and expense, any and all unfit and unsatisfactory workmanship or materials made use of in the construction of the said Building, and the said Architect and Building Committee shall jointly have the right to object to and to require the removal, change, and alteration of any and all materials and work not corresponding in quality and manner to those respectively designated in the specifications hereunto annexed, provided nevertheless, that such removal, change, or alteration shall be required within two weeks next after the setting up or use of the materials or doing of the work objected to as aforesaid. And it is further covenanted and agreed by and between the said parties, that if the said parties of the first part shall, within three calendar months next after the date of these presents determine to have the said Building constructed without the two Towers now marked on the plans hereby adopted, or to postpone the erection thereof, the sum of four thousand five hundred dollars shall be allowed by the said parties of the second part, and be deducted from the consideration money hereinbefore named; and further, that if by like determination and direction, the terra cotta chimneys and pinnacles according to the said plans and specifications, shall be omitted, the sum of eight thousand dollars shall be allowed and deducted from the consideration money aforesaid, provided nevertheless, that notice in writing of such intended omissions or alterations shall be given by the said parties of the first part within the said three months to the said parties of the second part. And it is hereby further covenanted and agreed by and between the parties hereto, that in case any other omissions, alterations, additions or extra work from or to the said designs, plans, and specifications shall, by the said Building Committee, be thought neces-

sary or expedient to be made or done during the course of the erection or construction of any part of the said Building or its appurtenances, the said omissions, alterations, additions, or extra work shall not in any way affect or invalidate these Articles of Agreement, but the particulars in writing of such proposed omissions, or alterations, or additions shall be signed and delivered by the said Building Committee, or the Chairman thereof, to the said William Struthers, John Struthers, and William Struthers, Jr., copartners as aforesaid, their several executors or administrators, who shall and will thereupon make and perform such additions or allow such omissions accordingly; and thereupon if the said parties of the first and second part cannot forthwith agree upon the proper increase to or abatement from the consideration money hereinbefore named on account of the said additions, alterations, extra work, or omissions, then the same shall be referred to the decision of three disinterested persons, one of whom shall be chosen by each of the said parties, and they two shall call in an umpire, and the joint award or determination of a majority of the said referees relative to the value of the said additions, extra work, alterations, or omissions, and of the consequent increase or abatement of the consideration money aforesaid shall be conclusive and binding upon both the said parties, their successors, or their executors and administrators respectively.

And it is hereby further covenanted and agreed by and between the said parties of the first and second parts, that during the construction of the said Building, and until the completion thereof and its delivery to the said The Trustees of the University of Pennsylvania, and their successors, the said William Struthers, John Struthers, and William Struthers, Jr., copartners as aforesaid, their several executors or administrators, shall and will save and keep harmless and indemnified the said parties of the first part and their successors from all actions, suits, costs, and penalties, by reason of any neglect of city ordinances, encroachments upon neighboring premises, or from any other misfeasance or nonfeasance, accident, neglect, or other cause whatsoever, by or through the acts or defaults of any person or persons employed by the said parties of the second part in the erection of the Building, and all losses, costs, damages, penalties, or expenses thereby incurred or occasioned, shall be borne, suffered, and paid for by the said parties of the second part, their several executors or administrators. And it is hereby further covenanted and agreed by and between the said parties hereto, that the said parties of the second part, when and as often as by the said Building Committee so required, shall and will insure the said Building, at the cost of the said contractors, from all general and special risks for such sums not exceeding two hundred thousand dollars, and in such fire insurance companies as the said Building Committee may approve, and shall and will forthwith assign and transfer the several polices of insurance to the said The Trustees of the University of Pennsylvania, and their successors, to be held by them until the completion and delivery of the said Building, as security against any loss that might occur by the destruction or

injury of the said premises. And the said parties of the second part do hereby covenant and agree to and with the said parties of the first part, that on the first Monday of each and every month, commencing with the first Monday of June next ensuing the date hereof, and thereafter until the said Building shall be finished, they, the said William Struthers, John Struthers, and William Struthers, Jr., copartners as aforesaid, their several executors or administrators, shall and will make out and furnish to the said Architect, or to the said Building Committee, a careful and detailed statement and exhibit of the materials used in and towards the actual erection and construction of the said Building, and of the work done thereon during the month next preceding, not including in such statement any materials intended or prepared for use therein, if the same be not at the date of such statement actually and permanently set up or worked into the said Building, in accordance with the plans and specifications hereby adopted, which said statement and exhibit shall be submitted to the said Architect, who shall examine and verify the same, and shall thereupon determine the fair cash value of the materials and work therein specified, and from and out of the amount of each and every monthly valuation as aforesaid, ten per centum thereof shall be reserved and retained by the said The Trustees of the University of Pennsylvania, and their successors, upon making each monthly payment as hereinafter provided, as a security and guaranty for the true and faithful performance of the agreements and covenants of the parties of the second part herein contained. And the said parties of the second part do hereby further covenant and agree with the said parties of the first part, that in case default shall be made in completing and finishing the said Building and its appurtenances, in accordance with these Articles of Agreement, and delivering the same to the said The Trustees of the University of Pennsylvania, and their successors, on or before the first day of August, in the year of our Lord one thousand eight hundred and seventy-two, it shall and may be lawful for the said parties of the first part to keep and retain out of any moneys in their possession to which, upon final settlement as hereinafter provided, the said William Struthers, John Struthers, and William Struthers, Jr., copartners as aforesaid, their executors or administrators, might or would be entitled, the sum of two thousand dollars for each and every calendar month, or the part of any calendar month, that default shall be made as aforesaid, not as a penalty, but as liquidated damages due by and received from the said parties so in default, and which liquidated damages the said William Struthers, John Struthers, and William Struthers, Jr., copartners as aforesaid, jointly and severally, and for their several executors and administrators, do and each of them doth hereby covenant and consent to be charged with, and to pay in the manner aforesaid to the said The Trustees of the University of Pennsylvania, and their successors. And the said The Trustees of the University of Pennsylvania, for themselves and their successors, do hereby covenant, promise, and agree to and with the said William

Struthers, John Struthers, and William Struthers, Jr., copartners as aforesaid, their several executors and administrators, that for and in consideration of the erection, construction, and finishing of the aforesaid Building with its appurtenances, in conformity with the plans and specifications hereby adopted or hereunto annexed, as well as of the true and faithful performance of all and every the covenants and agreements herein contained,on the part of the said parties of the second part, the said parties of the first part shall and will well and truly pay, or cause to be paid unto the said parties of the second part, the sum of two hundred and thirty-one thousand nine hundred dollars, subject to abatement therefrom or increase thereto in manner aforesaid, in the several instalments, and at the respective times hereinafter mentioned for the payment thereof, that is to say, in each and every month during the construction of the said Building, such sum as by the statement of materials used and work done, and the valuation thereof by the said Architect, shall appear to be due, whenever and as soon as such valuation shall be determined, first, nevertheless, deducting therefrom ten per centum of the amount thereof, to be reserved by the said parties of the first part as hereinbefore covenanted; and when and as soon after the said Building with its appurtenances shall be completely erected, constructed, and finished, and ready for immediate occupancy, and all stone, soil, rubbish, and superfluous matter shall have been entirely removed, and the said premises delivered up to the said The Trustees of the University of Pennsylvania, that then the said The Trustees of the University of Pennsylvania, and their successors, shall and will well and truly pay or cause to be paid unto the said William Struthers, John Struthers, and William Struthers, Jr., copartners as aforesaid, their several executors and administrators, the full and entire balance and residue of the said sum of two hundred and thirty-one thousand nine hundred dollars (subject to abatement therefrom or increase thereto, in manner aforesaid, or deduction therefrom on default of completing the said building within specified time) then remaining due and unpaid, including all sums of ten per centum reserved from each and every monthly settlement as aforesaid, it being understood that no interest shall accrue or be payable upon any sums so reserved.

And the said parties of the first part for themselves and their successors do hereby further covenant and agree to and with the parties of the second part, that upon the completion and delivery of the said building, they, the said "The Trustees of the University of Pennsylvania," and their successors, shall and will purchase all policies of insurance effected as hereinbefore provided, to an amount not exceeding two hundred thousand dollars, and will pay, therefore the amount of premium paid by the said parties of the second part for the said several insurances, excepting, nevertheless, such part of the said premiums as shall at any time have been paid for extra risks while building. And it is hereby further covenanted and agreed by and between the said parties hereto, that whenever so required by either of the said parties of the first or second parts, the work done, and the materials

used in and towards the actual erection aud construction of the building and its appurtenances during any preceding period, not including any materials intended or prepared for use therein, if the same be not bona fide and permanently set up or affixed in or to the said building in accordance with the plans and specifications aforesaid, shall be measured and estimated by three disinterested and competent persons, whereof one shall be chosen by each of the said parties, and they shall call in an umpire, and the joint award of a majority of the said referees, regard being had to the entire consideration money to be paid for the construction of the said building, shall be binding and conclusive upon both the said parties, their successors or executors and administrators respectively, and all the costs and charges of such measurement and valuation shall be shared equally between the said parties; and if, upon any such measurement and valuation, it shall appear that the aggregate of monthly statements and valuations hereinbefore provided for, inclusive of the ten per centum of deductions, shall be in excess or below the just and true amount owing for the work done and materials furnished as before said, such excess shall be charged to, or such undervaluation shall be compensated for at the monthly settlement next succeeding such measurement and award.

And the said William Struthers, John Struthers, and William Struthers, Jr., copartners as aforesaid, do hereby jointly and severally covenant and agree to and with the said "The Trustees of the University of Pennsylvania," and their successors, that upon the execution of these presents they shall and will furnish sufficient and satisfactory security by their joint and several Bond or Obligation in writing, with warrant of attorney to confess judgment thereon forthwith to the amount of twenty thousand dollars, to be given to them the said parties of the first part, for the full performance by the said parties of the second part of all agreements and covenants herein contained, concerning the erection of the said building and appurtenances, and its delivery, when completed, to the said parties of the first part; and further, that a full and legal release shall be duly executed by all persons who, under the laws of the Commonwealth of Pennsylvania, could or might file any lien on the aforesaid building and appurtenances for work done or materials furnished for constructing the same, the said bond to be held by the said parties of the first part, and the judgment entered thereon to remain unsatisfied for the space of six months after the entire completion of the said building, and its due delivery to them, or for such further term as by the laws of said Commonwealth then in force may be necessary for a full and entire protection against any and every lien as aforesaid. And it is hereby further covenanted and agreed by and between the said several parties hereto, that the said "The Trustees of the University of Pennsylvania," and their successors, shall be represented in all matters, agreements, alterations, settlements, supervision, and other necessary acts whatsoever relative to or concerning the erection of the said building and its appurtenances, and the fulfilment of these articles, by a building committee duly appointed by

the said "The Trustees of the University of Pennsylvania," and all said agreements and acts of the said building committee shall be as valid and binding to all intents and purposes upon the said "The Trustees of the University of Pennsylvania," and their successors, and upon the said William Struthers, John Struthers, and William Struthers, Jr., copartners as aforesaid, their several executors or administrators, as if formally entered into by and with the said "The Trustees of the University of Pennsylvania" under their corporate seal.

In testimony whereof the said "The Trustees of the University of Pennsylvania" have caused these presents to be sealed with their corporate or common seal, and the said William Struthers, John Struthers and William Struthers, Jr., copartners as aforesaid, have hereunto severally set their hands and seals the day and year first before written.

This was followed by an agreement authorizing the majority of the "Building Committee" to represent the trustees.

General Form of Contract Between a Firm and Contractor.

Articles of Agreement, made and concluded this day of Anno Domini One Thousand Eight hundred and by and between party of the first part, and party of the second part.

Witnesseth, That for and in consideration of the payments and covenants hereinafter mentioned to be made and performed by the said party of the second part, the said party of the first part doth hereby covenant and agree to

The whole of the said work to be erected, constructed and finished, in conformity with the instructions which shall from time to time be given by the Engineers and Architects of the party of the second part, and in full accordance with the plans thereof prepared by and with the specifications, a copy of which is hereunto attached, which plans and specifications are understood as forming part of this agreement. The aforesaid work to be commenced and finished on or before the day of Anno Domini One Thousand Eight Hundred and And the said party of the second part doth hereby promise and agree to

pay to the said party of the first part for the full and faithful performance of this contract the sum of dollars.

Payment to be made in the following manner, to wit;

And when all the work embraced in this contract is completed agreeably to the specifications and in accordance with the directions and to the satisfaction of the Engineers and Architects, there shall be a final estimate made of the quantity, character and value of said work, agreeably to the terms of this agreement, when the balance appearing due to the said party of the first part, shall be paid to upon giving a release under seal to the said party of the second part from all claims or demands whatsoever growing in any manner out of this agreement, and upon presenting clear evidence satisfactory to the Engineers and Architects that all bills and claims against that in any way might remain as a lien against this work are fully paid and discharged.

The said party of the first part further agrees that before any payments are made to by said party of the second part under this contract will execute to said party of the second part bonds in the sum of dollars, with satisfactory security to said party of the second part for the faithful performance of this contract and indemnifying the said party of the second part from all loss, cost or damages, for or by reason of any liens, claims or demands for materials, or from laborers, mechanics and others, or from any damages arising from accidents to mechanics or laborers employed in the construction of said building, or for damages resulting to persons passing on streets on which the is being constructed, or for damage done to adjacent properties by the construction of said , or by depositing material in such a manner as to damage either the City or the individual; said bonds and security to be and remain in force for months after said shall have been completed and accepted.

It is further agreed and understood that should the party of the first part refuse, neglect or from any cause fail to prosecute the work with a force of men and supply of materials sufficient in the opinion of the Engineers and Architects for its completion within the time specified in this agreement, then and in that case the Engineers and Architects or such agent as they shall designate, may proceed to employ such a number of workmen, overseers and laborers and purchase such materials as may in the opinion of said Engineers and Architects be necessary to insure the completion of the work within the time hereinbefore limited at such wages and prices as they may find it necessary or expedient to give, pay all indebtedness so incurred, and charge over the amount so paid to the party of the first part as for so

much money paid to said party of the first part on this contract: or the said Engineers and Architects may at their discretion, for the failure to prosecute the work with an adequate force, for non-compliance with their directions in regard to the manner of constructing it, or for any other omission or neglect of the requirements of this agreement and specifications on the part of the party of the first part, declare this contract or any portion or section of it forfeited; which declaration and forfeiture shall exonerate the said party of the second part from any and all obligations and liabilities arising under this contract, the same as if this agreement had never been made, and any reserved percentage or balances unpaid upon any work done by the said party of the first part may be retained forever by said party of the second part.

It is mutually agreed between the parties to this agreement, that if any changes, alterations or omissions are made in the building during the progress of the work, the value of such changes, omissions or alterations shall be decided by the Engineers and Architects, who shall make an equitable allowance for such changes, omissions or alterations, and shall add the amount of said allowance to the contract price for the work if the cost of the work has been increased, or shall deduct the amount from the contract price if the cost of the work has been lessened, as they the said Engineers and Architects may deem just and equitable.

And it is mutually agreed and distinctly understood that the decision of the Engineers and Architects shall be final and conclusive in any dispute which may arise between the parties to this agreement, relative to or touching the same, and each and every of said parties do hereby waive any right of action, suit, or suits or other remedy in law or otherwise, by virtue of said covenants, so that the decision of the said Engineers and Architects shall in the nature of an award be final and conclusive on the rights and claims of said parties.

In witness whereof,

Form for "Right of Way" Grant in Fee.

This Indenture, made this day of 187 between of the County of State of Pennsylvania, party of the first part, and the Company, parties of the second part, witnesseth:

That for, and in consideration of one dollar, lawful money, by the parties of the second part to the said party of the first part well and truly paid before the ensealing and delivery of these presents, the receipt whereof is hereby acknowledged; subject to the further payment of

dollars, to be paid when work is commenced on the lands of the party of the first part, the said party of the first part does hereby grant, bargain, sell, assign, convey, confirm, release and set over unto the said parties of the second part, their successors and assigns, a certain strip of land lying along the located line of the Company, as the same has been now, is, or may hereafter be located, not to exceed one-half rod on each side of said centre line, with the right of said party of the second part by themselves or their employees, to enter upon said lands lying in the county aforesaid, for the purpose of constructing one or more lines of pipe with necessary stations and telegraph, and of maintaining the same forever. Reserving, however, the right to the party of the first part in all cases where the land is under or susceptible of cultivation, to use the same for that purpurpose, and also reserving all minerals therein.

And the said
for himself and his heirs, executors and administrators, doth covenant with the parties of the second part and their successors and assigns, to warrant and defend the said parties of the second part and their successors and assigns, in the full and free enjoyments of all, and singular the premises and rights hereby granted, against all persons whomsoever.

In witness whereof, the said parties of the first part have hereunto set their hands and seals the day and year first above written.

Signed, sealed and delivered [Seal.]
in presence of

[Seal.]

County of
State of Pennsylvania. } ss.

This day of A. D. 187 before me, the subscriber a of said county, personally appeared the above named who, in due form of law, acknowledged the foregoing Indenture to be act and deed, and desired that the same might be recorded as such.

Witness my hand and seal the day and year last above written,

[L. S.]

Preliminary Agreement to Grant a "Right of Way."

Know all men by these presents, that.................................. ....for and in consideration of the advantages to be derived from the location and construction of the railroad as hereinafter mentioned, and of the sum of........dollars to........in hand paid by The......... ....Company at or before the execution hereof, the receipt whereof is hereby acknowledged, and of the further sum of..............dollars lawful money to be paid to......by the said Company upon the execution and delivery of the conveyance or release hereinafter mentioned, do hereby, for........heirs, executors, administrators, and assigns, grant to the said Company, their successors and assigns, the privilege of surveying, locating, constructing, and using, by themselves, their engineers, contractors, agents, and employees, a railroad upon such line or route therefor as may be adopted by said Company, through, over, and upon a certain tract or parcel of land belonging to....situate in.....Township,........County, and State of............a plan whereof, more particularly showing said line or route of said railroad, may be hereto attached.........................

And.....do also, for....heirs, executors, administrators, and assigns, hereby covenant and agree to execute and deliver to the said The......... Company, their successors and assigns, a proper deed of conveyance, or release for the right of way for the said railroad, through the whole length or breadth of the above mentioned tract of land, if required, said right of way to be not over....feet wide, with such additional widths for slopes at deep cuttings, embankments, retaining-walls, bridges, and drains as may be required for the proper construction, maintaining, and operating of said railroad; and further, to release the said Company, their successors and assigns, from all claims and demands for damages which may accrue to...... heirs, executors, administrators, or assigns by reason of the taking and using of the said land for said railroad, or by reason of the construction, maintaining, and operating said railroad on and over said tract or parcel of land.

....

....

Witness....hand and seal, the....day of.......one thousand eight hundred and......

Sealed and delivered in presence of ....(Seal)

................(Seal)

................(Seal)

On the........day of........A. D. 18..before me, the subscriber...... ....personally appeared the above named.................who in due form of law acknowledged the foregoing agreement to be......act and deed, and desired that the same might be recorded as such.

Witness my hand and seal the day and year aforesaid.

.......................(L. S.

Deed for Right of Way.

Know all Men by these Presents, That whereas the Company have located or are about to locate their Rail upon and through certain tract , piece or parcel of land, situate in Township, County, State of bounded by lands of

and being the property of the undersigned: Now, therefore,

for and in consideration of the location of the said rail over lands, and of the advantages which may accrue to therefrom, and also of the sum of dollars to in hand paid, at and before the ensealing of these presents, have granted, bargained, sold and conveyed, and by these presents do grant, bargain, sell and convey to the said Company, their successors and assigns, for the uses and purposes of their rail and the construction of works connected therewith, the right of way through and over said lands the whole distance of said rail through the same, and in width feet, and with such additional width as may be required and necessary in the construction and use of a double-track rail at deep cuttings and embankments, one-half thereof on each side of the centre line of the double track of said rail. a plan of which said strip of land and premises is hereto annexed, and the full liberty to make, maintain and use the said rail over said lands, with the usual road-bed, slopes, berms, ditches, spoil-banks and borrow pits, and also the right to take and use any water from springs or streams upon said lands, and to conduct and carry water, by pipes or otherwise, over or through said lands, and to establish water stations thereon.

To Have and to Hold the said strip of land and the said rights and privileges to the said Company, their successors and assigns, so long as the same shall be required for the uses and purposes of said rail . And for the considerations aforesaid, do hereby for heirs, executors, administrators, and assigns, release the said Company, their successors or assigns, from any further payments for or on account of the appropriation and occupancy of the said strip of land, as well as for any and all damages which have accrued, or which may hereafter ac-

crue, by reason of the location, construction, and operating of the said rail over and upon the said lands,

In Witness Whereof, have hereunto set hand and seal the day of A. D. one thousand eight hundred and

Sealed and delivered in the presence of us: [L. S.]

[L. S.]

[L. S.]

[L. S.]

Received, The date of the within indenture, of the Company, the sum of being the full consideration money within mentioned.

Witnesses present:

.... *s s.*

On the day of Anno Domini 18 before me, one of the in and for the said personally appeared the within-named and in due form of law acknowledged the within instrument of writing to be act and deed, and desired that the same might be recorded as such. And the said being of full age, and separate and apart from said husband by me thereon privately examined, and the full contents of the within instrument of writing being by me first made known unto did thereupon declare and say, that did voluntarily, and of own free will and accord, sign, seal, and as act and deed, deliver the within instrument of writing, without any coercion or compulsion of said husband.

Witness my hand and seal the day and year aforesaid,

County of
State of Pennsylvania. } ss.

Recorded in the office for recording deeds, &c., in and for the County aforesaid, in Deed-book No. page &c.

Witness my hand and seal of office, this day of A. D. 18 .

Plan of the land referred to in the annexed deed——Scale feet to one inch.

(N. B.—It is of vital importance that the plot of the property with the direction of the line of the proposed improvement be entered in this place.)

CONTRACT

FOR GRADUATION AND MASONRY OF ROADS AND RAILROADS AS USED ON THE PENNSYLVANIA, AND PHILADELPHIA & READING RAILROADS.

See pages 150, 232.

ARTICLES OF AGREEMENT, made and concluded this day of A. D. one thousand eight hundred and seventy between of the first part, and of the second part, witnesseth, that for and in consideration of the payments and covenants hereinafter mentioned, to be made and performed by the said party of the second part, the said party of the first part doth hereby covenant and agree to construct and finish, in the most substantial and workmanlike manner, to the satisfaction and acceptance of the Engineer of the all the graduation, masonry, and such other work as may be required on of said road; the said work to be finished as described in the following specifications, and agreeably to the directions, from time to time, of the said Engineer or his assistants, on or before the day of in the year one thousand eight hundred and .

(Note.—The specifications as printed on page 150 are here introduced.)

And the said party of the second part doth promise and agree to pay to the said party of the first part, for completing this contract, as follows, viz.: For excavation of earth, cents per cubic yard. For loose rock, cents per cubic yard. For solid rock, cents per cubic yard. For embankment, cents per cubic yard. For masonry of rectangular culverts, dollar cents per cubic yard. For semi-circular or other culverts with curved arches, dollar cents per cubic yard. For bridge masonry, first quality, dollar cents per cubic yard. For bridge masonry, second quality, dollar cents per cubic yard. For paving in foundations of culverts, dollar cents per cubic yard. For vertical wall, dollar cents per cubic yard. For slope wall, dollar

cents per cubic yard. For rip rap For timber laid in foundation of bridges and culverts, per cubic foot, cents.

On or about the first day of each month, during the progress of this work, an estimate shall be made of the relative value of the work done, to be judged of by the Engineer; and upon his certificate of the amount being presented to the said party of the second part, or such disbursing agent as they may appoint, four-fifths of the amount of said estimate shall be paid to the party of the first part, between the 10th and 20th of each month, at such time and place as the said disbursing agent may designate: Provided, The amount due on said estimate to the party of the first part shall be more than three hundred dollars; and when all the work embraced in this contract is completed agreeably to the specifications, and in accordance with the directions and to the satisfaction and acceptance of the Engineer, there shall be a final estimate made of the quality, character, and value of said work, agreeably to the terms of this agreement, when the balance appearing due to the said party of the first part shall be paid to upon giving a release, under seal, to the said party of the second part, from all claims or demands whatsoever growing in any manner out of this agreement. It is also understood, that the party of the first part will make all payments, for the work herein contracted for, in such funds as may receive from the party of the second part.

It is further covenanted and agreed between the said parties, that the said party of the first part shall not let or transfer this contract, nor any part thereof, to any other person, (excepting for the delivery of materials,) without the consent of the party of the second part, but will give personal attention and superintendence to the work. Nor shall the said party of the first part employ any person or persons who commit depredations on the neighborhood, or insult travelers or other persons; and all such disorderly persons shall be discharged from employment, whenever the said party of the first part shall be directed so to do by the Engineer in charge of the work. The said party of the first part further bind not to keep, or suffer to be kept or used, any ardent spirits in any house or tenement built or occupied by or by the workmen, or boarding-house keepers under on or near said road; and to discharge from employment any workman, laborer, or boarding-house keeper who is guilty of a breach of this regulation, when required by the Engineer.

The Chief Engineer shall have the right to regulate, from time to time, the wages of labor upon the line of the work, so as to maintain a proper distribution of the force, and prevent the injurious effects of competition among the contractors for hands.*

It is further agreed and understood that the work embraced in this contract shall be commenced within days from this

* This clause is not in use on the Pennsylvania Railroad.

date, and prosecuted with such force as the Engineer shall deem adequate to its completion within the time specified; and if, at any time, the said party of the first part shall refuse or neglect to prosecute the work with a force sufficient, in the opinion of the said Engineer, for its completion within the time specified in this agreement, then, and in that case, the Engineer in charge, or such other agent as the Engineer may designate, may proceed to employ such a number of workmen, laborers, and overseers as may, in the opinion of the said Engineer, be necessary to insure the completion of the work within the time hereinbefore limited, at such wages as he may find it necessary or expedient to give; pay all persons so employed, and charge over the amount so paid to the party of the first part, as for so much money paid to said party of the first part on this contract; or the said Engineer may, at his discretion, for the failure to prosecute the work with an adequate force, for non-compliance with his directions in regard to the manner of constructing it, or for any other omission or neglect of the requirements of this agreement and specifications on the part of the party of the first part,—declare this contract, or any portion or sections embraced in it, forfeited; which declaration and forfeiture shall exonerate the said party of the second part from any and all obligations and liabilities arising under this contract, the same as if this agreement had never been made; and the reserved percentage of one   upon any work done by the party of the first part may be retained forever by the said party of the second part; and it is mutually agreed and distinctly understood, that the decision of the Chief Engineer of the said   Railroad shall be final and conclusive in any dispute which may arise between the parties to this agreement, relative to or touching the same; and each and every of said parties do hereby waive any right of action, suit or suits, or other remedy in law or otherwise, by virtue of said covenants, so that the decision of said Engineer shall, in the nature of an award, be final and conclusive on the rights and claims of said parties.

In witness whereof, the said parties

ha hereunto set hand and seal the day and year first above written.

Witness:

[Seal].
[Seal].
[Seal].
[Seal].

QUESTIONS ON THE SIXTH CHAPTER.

Page 243. What is a contract? What are its component parts? How many copies should be signed?

Page 244. How are they classified? Define the different grades.

Page 245. What are the four essential elements? Who may be parties to a contract and who not? Of what value is a compulsory signature?

Page 246. Is a party bound by the signature of his agent? How are corporations regarded? What is mutual consent? How does fraud affect the validity of a contract? What is assent? What is an offer on time? How long is an offer by letter good? Of what use is the consideration? Define it. What is the distinction between a *good* and a *valuable* consideration?

Page 247. How is the existence of a seal to be interpreted? Is the validity affected by the adequacy of the consideration? What is the effect if it be illegal or impossible? What if a valuable consideration becomes worthless before part performance? Upon what subjects may contracts be made? How is the intention of the parties to be interpreted? What is the difference between an oral and written agreement? Upon what points may evidence be received in written contracts?

Page 248. How are words to be interpreted? If wording be obscure what results? What influence has the customary or local meaning of a word or phrase? What other elements may be introduced in an agreement to modify its terms and conditions? How are the duties of the parties to be stated? What are those of the contractor? of the employer? How may payments be made? Upon whom does the risk rest? May contractor claim a payment before acceptance of work? What are the stipulations when payments are made by instalment? May the certificates of an expert be required? What is the ruling in case of penalties for delay?

Page 250. How does a breach of contract by the employer affect the obligations of the contractor? What effect has extra work? What time may be allowed when none is specified? When does a given time expire? What is meant by a month? What is the limitation for simple cases? for sealed instruments? When is the guaranty required? What is it?

Page 251. Give the substance of the law relating to Government contracts; relating to appropriations for public works. Analyze the form given for use by the U. S. Engineers, indicating the general and several duties of the parties.

Page 253. Fill up the bond.

Pages 254, 256, 257. What are the conditions imposed in the form of Light-House contract? What bonds and certificates are required ?

Page 259. Analyze carefully the form of contract for a sewer.

Pages 262, 263. What are the elements of the contracts for a Reservoir and the general form for Iron Pipes for Aqueduct on page 273?

Page 275. What are the stipulations for a Grant of Right of Way in fee ?

Page 277. State the conditions of the preliminary agreement for Right of Way.

Page 278. What is the form of deed for Right of Way for a R. R., &c.

Page 280. Analyze the form of Agreement for Graduation and Masonry.

(Students should now be required to prepare *all* the papers for a complete contract, including the proposals and drawings, and endorse them for filing away.)

APPENDIX A.

General Specifications

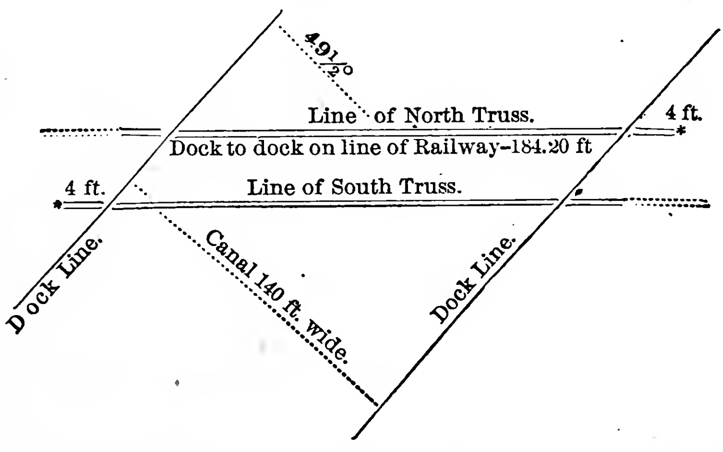
FOR A WROUGHT IRON RAILWAY DRAW BRIDGE TO BE ERECTED FOR THE CHICAGO, MILWAUKEE AND ST. PAUL RAILWAY COMPANY OVER CANAL IN THE CITY OF MILWAUKEE, WISCONSIN.

The guage of the Railway is four feet eight and one-half inches.

The entire superstructure will be of wrought iron, including floor-beams and track-stringers, except wheel tracks and wheels for turn table and end adjustments, rack and pinion for turning and centre pedestal, which may be of cast iron or steel.

The structure will be a double track through span, and may have either two or three trusses. If the former, the tracks will be placed twelve (12) feet apart between centres, and the width in the clear between trusses must be twenty-six (26) feet. If the latter, there must be fourteen (14) feet in the clear in each roadway. The height in the clear from top of rail to any upper lateral member must be at least nineteen (19) feet.

Length of Span.—The length of the span must be such as to fit the Crossing shown on the following diagram, with the proviso that the centre of the end bearings must be at least four (4) feet inside of the dock line, measured from the dock line on a line parallel to the line of track.



The span may be built either square or skew ended, provided that in the latter case it is properly balanced on the turntable.

The height from top of masonry of pivot pier to base of rail must not exceed ten (10) feet.

The draw span will be rotated by hand power, and the end screws, latches, etc., must be arranged to work rapidly and from the middle of the span.

Quality of Iron.—The iron subject to tensile strain shall be tough, ductile and of uniform quality, capable of sustaining not less than 50,000 lbs. per square inch of sectional area when tested in large and long lengths, to have an elastic limit of not less than 26,000 lbs. per square inch; the reduction of breaking area shall average 25 per cent., and the elongation of the bar before rupture to be at least 15 per cent., and when cold a round bar 1½ inch diameter must bend through 180° without sign of fracture.

The iron subject to compressive strain must be tough, fibrous, uniform in quality, and have an elastic limit of not less than 25,000 lbs per square inch.

All cast iron in wheels or in minor details must be of good, tough metal, of such quality that a bar five feet long, one (1) inch square, 4 feet 6 inches between knife edge supports will sustain a weight of 500 lbs. on knife edge at centre without breaking.

The pins and all parts subject to shearing or bending strains shall be of the best quality of wrought iron.

Weight of Structure and Moving Load.—In determining the total weight of the structure for the purpose of calculating strains, add to the total weight of iron in the trusses, lateral system, floor beams and track stringers, 700 lbs. per foot of bridge for weight of rails, splices, spikes, cross ties and guard timbers for the two tracks. From the dead weight thus determined and the live load hereinafter specified the proportion parts will be determined.

Chords will be proportioned as follows:

CASE 1.—Spans swinging and unloaded.

CASE 2.—Spans in position and ends touching their bearings, but without end reactions; and both spans covered with a uniform rolling load of 2,600 lbs. per foot on each track.

CASE 3.—Spans closed and the ends raised until the points of contraflexure are one-third of each span distant from the turntable supports, and both tracks of one arm loaded with a uniform load of 2,800 lbs. per foot on each track.

Strains in Main-ties will be determined from cases of loading 1 and 2, and by assuming a train on each track weighing 2,800 lbs. per foot, headed by an engine occupying 24 feet of track, and concentrating 72,000 lbs. on three (3) pairs of drivers in 12 feet, and moving abreast from one end pier to the centre.

Strains in Counter-ties will be determined by assuming that the above described trains are moving from the centre to the end of one arm while the bridge is raised at the ends, as in case 3.

The maximum strains in each case shall be taken in proportioning any tie, counter-tie or post.

Tensile Members.—The tension members shall be so proportioned that the maximum strains produced by the weight of the structure, and the speci-

fied moving and engine load shall in no instance exceed the following, viz:

For tensile strains in primary members of the truss, or those upon which the principal weight comes directly from the floor-beam. . .	8,000 lbs. per square inch.
For strains in secondary members, or those which receive their principal strains through the primaries, ...	9,000 lbs. per square inch.
Strains in tertiary members, ...	10,000 lbs. per square inch.
Strains in end suspenders, ...	8,000 lbs. per square inch.
Strains in common floor-beam suspenders, .	4,000 lbs. per square inch.

The foregoing are the strains to be used where the specified members are eyebars or bolts, but if they consist of riveted sections the strains allowed shall be as follows:

For splice plates in tension, ...	7,500 lbs. per square inch.
For riveted members in tension in chords, .	8,500 lbs. per square inch.
For riveted members in tension in web, .	8,000 lbs. per square inch.

When any member is exposed to strains in opposite directions, the sections shall be determined by the following formula, in which S represents the sectional area in square inches required, and the column strength per square inch is determined by the formulæ hereinafter given.

$$S = \frac{\text{MAXIMUM TENSION.}}{10{,}000.} + \frac{\text{MAXIMUM COMPRESSION.}}{\dfrac{\text{Column strength per square inch.}}{4}}$$

Provided that the section thus found shall not be less than required by the foregoing specifications for members in tension, or the following specifications for members in compression:

Crippling Strains.—The ultimate crippling strength in lbs. per square inch of section of the several forms of posts, struts and chords will be determined by the following formulæ, in which formulæ H equals the length between the end bearings in terms of the least diameter.

	SQUARE COLUMN.	PHŒNIX COLUMN.	AMERICAN COLUMN.	COMMON COLUMN.
Flat Ends	$\frac{38{,}500}{1+\frac{H^2}{5820}}$	$\frac{42{,}500}{1+\frac{H^2}{4500}}$	$\frac{36{,}500}{1+\frac{H^2}{3750}}$	$\frac{36{,}500}{1+\frac{H^2}{2700}}$
One Pin End	$\frac{38{,}500}{1+\frac{H^2}{3000}}$	$\frac{40{,}000}{1+\frac{H^2}{2250}}$	$\frac{36{,}500}{1+\frac{H^2}{2250}}$	$\frac{36{,}500}{1+\frac{H^2}{1500}}$
Two Pin Ends	$\frac{37{,}800}{1+\frac{H^2}{1900}}$	$\frac{36{,}600}{1+\frac{H^2}{1500}}$	$\frac{36{,}500}{1+\frac{H^2}{1750}}$	$\frac{36{,}500}{1+\frac{H^2}{1200}}$

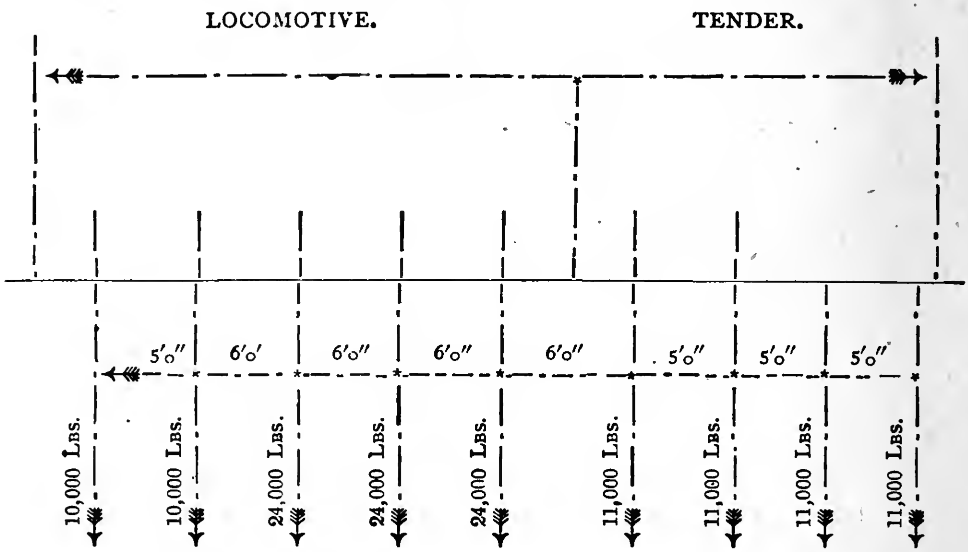
The pin being so placed that the moment of inertia is, as near as practicable, equal on both sides of same, use formulæ for square column.

The maximum strain permitted in any purely compressive member will be the quotient resulting from dividing the ultimate strength, as determined by the above formulæ, by a coefficient of safety, equal to $4+\frac{5H.}{100}$ "H," as before being the measure of length in terms of least diameter.

Wind Strains shall be calculated at 30 lbs. per square foot on twice the surface of one truss, plus ten (10) square feet per foot of bridge for car surface, and the resulting strains therefrom shall be resisted by lateral and vertical rods proportioned to 15,000 lbs. per square inch in tension, and lateral struts proportioned to a factor of safety of four (4).

Shearing and bending strains at the lateral connections shall be calculated with the same precision as the main strains, and shall be resisted by members proportioned so that the maximum shearing strain shall not exceed 10,000 lbs. per square inch, and the maximum flexure or bending strain shall not exceed 22,500 lbs. per square inch.

Floor-Beams and Track-Stringers.—The floor-beams shall be proportioned for the concentration of weight produced by two of the following engines (one upon each track) resting with their middle drivers on the same floor-beam or over the same panel-point.



To this live load there shall be added 25 per cent. for momentum and the dead weight of the floor and stringers; and the resulting strains therefrom shall not exceed 8,000 lbs. per square inch in compression or 10,000 lbs. per square inch in tension.

The stringers immediately under the rails shall be proportioned to carry the above described engine weight plus 30 per cent. for momentum and their proper proportion of floor, and subject to the same conditions as to limit of tensile and compressive strains as specified above for floor-beams.

If the floor-beams and stringers are of built sections, the rivets must be so spaced that between the points of application of the load and the points

of support there are rivets enough to transmit the flange strains to the web and from the web to the flange, without exceeding a shearing strain of 7,500 lbs. per square inch upon the rivets, or of 8,000 lbs. per square inch of mean pressure on the semi-intrados of the rivet holes.

In case the bridge is designed with three trusses, there will be an exterior pair of iron safety stringers placed 3 feet outside of the main stringers on each track. In case the bridge is designed with two trusses, there will be an iron safety stringer 3 feet outside of the outer main track stringer of each track and one midway between the inner main track stringers of the two tracks. These safety stringers will be proportioned to one-half the strength of the track stringers under the rails.

Pins.—The shearing strain on any pin must not exceed 7,500 lbs. per square inch of its sectional area. The strain on extreme fibres caused by bending, must not exceed 15,000 lbs. per square inch, and in determining this bending strain, the leverage distance shall be considered as from centre of eyebar to centre of bearing or of opposite eyebar.

No pin shall have a less diameter than two-thirds of the width of the widest eyebar coming upon it.

The bearing surface of any pin on chord, tie or post shall not be exposed to a greater strain than 8,000 lbs. mean pressure on the semi extrados.

Pins must be turned true to size and straight, no error of more than $\frac{1}{50}$ of an inch in diameter being allowed.

Eyebars.—Pinholes in eyebars shall be bored to exact sizes and distances, and to a true perpendicular to the line of strain. No error in length of bar or diameter of pinhole exceeding $\frac{1}{64}$ of an inch will be allowed.

The section of metal in the eye opposite the centre of the pinhole and perpendicular to the line of strain, shall be proportioned according to the following table, the diameter of the bar being the unit:

HYDRAULIC FORGED EYES.

ON WELDLESS BARS.

Pin.	Bar.	Eyesection.
0.67	1.0	1.50
0.75	1.0	1.50
1.00	1.0	1.50
1.25	1.0	1.60
1.33	1.0	1.70
1.50	1.0	1.85
1.75	1.0	2.00
2.00	1.0	2.20

HAMMERED EYES,

WELDED TO BARS.

Pin.	Bar.	Eyesection.
0.75	1.0	1.33
1.00	1.0	1.50
1.25	1.0	1.50
1.50	1.0	1.67
1.75	1.0	1.67
2.00	1.0	1.75

No eye on a weldless bar shall have a metal section less than 1½ times the area of bar, and for hammered eyes the least eye-section shall be 1⅓ the section of the bar.

A drawing of the standard shape of the eye proposed to be used must be filed with each proposal.

Riveted Work.—In riveted work all joints shall be square and truly dressed. Rivet holes shall be accurately spaced, and the rivets must be of the best quality of iron for the purpose, and completely fill the holes.

All rivets with crooked heads or heads not formed centrally on the shank, or rivets which are loose either in the rivet hole or under the shoulder, shall be cut out and new ones put in their places.

Rivet holes shall not be spaced less than 2½ diameters between centres, nor more than 16 times the thickness of the thinnest outside plate apart—nine (9) inches being the maximum pitch allowed in plate riveting.

No rivet hole shall be less than 1¾ diameters from the end of a plate, or 1½ diameters from the side of a plate, nor *ever* nearer than 1½ inches from centre of hole to edge of plate.

The diameter of the hole shall in no case be more than $\frac{1}{16}$ of an inch more than the diameter of the rivet.

When two or more thicknesses of plate are riveted together in compressive members the outer row of rivets shall not be more than three (3) diameters from the side edge of plates.

All joint rivet holes must be so accurately spaced that rivets of the proper size can be passed through all the holes in the joint after the parts are placed in position without the use of drift pins.

Unless abutting surfaces are machine-faced the transmission of compressive strains shall be considered as entirely through the medium of rivets and connection plates, and these must be proportioned accordingly.

No inaccurate or otherwise defective work will be accepted under any circumstances in connection joints of riveted work.

In members consisting of two or more pieces of shape iron connected by lattice or lacing bars, there shall be connection plates at each end, the row of rivets in which shall be not less than one diameter of the member in length.

In all posts and chords the connecting rivets within two diameters of the ends shall be equal to the sectional area of three joined pieces, and in posts and elsewhere in all riveted work the distance between rivet supports across the plate shall not exceed thirty (30) times the thickness of the plate, and no closed sections shall have members of less thickness than $\frac{5}{16}$ of an inch.

All rivets in splice or tension joints must be symmetrically arranged so that each half of a tension member or splice plate will have the same uncut area on each side of its centre line.

For riveted members in compression the rivet holes need not be deducted, but for members in tension only the minimum uncut section will be considered.

No rivet shall be exposed to more than 7,500 lbs. per square inch in shear, or more than 8,000 lbs. mean pressure per square inch of semi-extrados.

Bed Plates and End Supports.—The bed plate supporting turn table centre shall be so proportioned that the pressure on the masonry shall not exceed 25,000 lbs. per square foot while the span is rotating and the pressure

of the wheel track and end supports of span on the masonry shall not exceed this limit when the bridge is fully loaded as heretofore specified.

Turn Table.—The turn table may be a centre-bearing, rim-bearing, or combined rim and centre bearing table. If the first, it must be so designed that the rim wheels bear no weight while the bridge is turning, and the truss or girder by which the weight is carried to the centre must be proportioned according to the same specifications as for the main truss.

If a wearing or friction centre-pin is used, the pressure while rotating shall not exceed 6,000 lbs. per square inch, and the construction shall be such that the weight can be readily transferred from the pin to the rim wheels in order to put in a new pin or friction disc.

If a lubricated centre-pin is used, the weight while turning must not exceed 1,000 lbs. per square inch on the spindle bearing.

If a Sellers centre is used, the rotating load per lineal inch on the steel rollers shall not exceed that given by the following formula for steel rollers on steel plates:

$P=\sqrt{3{,}072{,}000.d}$ in which formula

P=pressure per lineal inch of roller, and

d=mean diameter in inches.

If a rim-bearing table is used, the circular girder must be of sufficient strength at the points of application of the load to carry the weight when the span is loaded, to the adjoining wheels, in case the wheel immediately under the point of support is not bearing. With this class of table the wheels must be faced to an exact size, the upper and lower wheel tracks planed to the true level, be of a face ¾ of an inch wider than the tread of the wheels, and during the rotation of the span all the wheels must turn.

The load per lineal inch of face of wheel while the span is turning shall not exceed that given by the formula

$$P=\sqrt{352{,}000.d}$$

for cast iron wheels upon wrought iron wheel track.

For cast iron wheels upon cast iron wheel track, the load per lineal inch of face of wheel while the span is turning shall not exceed that given by the formula

$$P=\sqrt{222{,}222.d}$$

For steel wheels upon steel track, use the following formula as to limit of pressure per lineal inch of wheel face, viz:

$$P=\sqrt{1{,}296{,}000.d}$$

For steel wheels upon wrought iron track, use

$$P=\sqrt{1{,}024{,}000.d}$$

And for steel wheels upon cast iron wheel track, use the formula

$$P=\sqrt{850{,}000.d}$$

The edges of the rim of the bearing and trailing wheels will be beveled to an angle of 45° from the line of face for a width of ⅜ inch on each side,

and the tread will be of the width necessary to meet the requirements of the given formulæ as to limit of pressure; and the metal forming said rim and that forming the web and hub of the wheel shall be of such thickness and form as will insure a strength proportionate to that of any part of the structure.

If a combined rim and centre bearing table is used, the division of the weight between the two systems shall be clear and unambiguous, and the proportions, etc., shall be determined by the foregoing specifications.

In any case, the arrangement must be such that the bearing or trailing wheels, or rollers, can be readily removed if broken, and the frictional constant at the centre line of the outer wheel circle shall not exceed $\frac{7}{1000}$ of the rotating weight.

The table shall be so designed that it will not require a masonry centre-pier of more than 32 feet in diameter.

The lower circular track, circular rack, centre pedestal and end bed plates shall be securely bolted to the masonry, and in such manner as will easily permit adjustment in case of unequal settlement of the stonework.

Workmanship, Painting, &c.—All workmanship must be first class, abutting joints must be truly planed and dressed so as to secure a perfect bearing, and the pinholes in chords and posts shall be bored as truly as is specified for eyebars.

The parts composing the posts or struts, must be of entire lengths without splicing between end bearings.

All closed work, such as posts, struts, chords, etc., must have two (2) coats of approved metalic paint and boiled oil on the enclosed surface, and one coat on the exterior surface before leaving the shop.

All turned and faced parts to receive a coat of tallow mixed with white lead before shipment. All rivets driven at the bridge site shall receive one coat of paint and all nuts must be checked.

In all the exposed iron work, enclosed spaces must be so constructed or provision made so as to prevent the lodgement of water.

Any work or part necessary to complete the entire structure in all respects in a first class manner, and which is not definitely specified herein, shall be supplied without extra charge by the contractor, and to the entire satisfaction of the Engineer of said Railway Company.

All detail drawings, before going into the shop to be worked from, shall be submitted for the approval of the Chief Engineer; and no work shall be begun or finished according to drawings which have not received his approval and signature; but such approval and signature will not relieve the contractor from making good at his expense any error in said drawings that may, through oversight, escape the observation of said Chief Engineer.

Tests.—A skilled inspector will be retained by the Railway Company, who will examine and test the iron at the rolling mill before it leaves for the shop, and who will have the shop work under his constant supervision, with full power of rejection whenever the specifications are not complied with.

The said Engineer of the Railway Company shall have the privilege of selecting, at any time before the erection of the bridge, any of the manufactured iron members and submit the same to such tests as he may deem proper, and should any of the members thus tested fail to be of the standard demanded, this will be considered sufficient evidence that the iron for the bridge does not comply with the specification, and will cause its rejection.

Reasonable compensation will be allowed for all finished material of good quality destroyed in making such tests.

All bars subject to tensile strain shall be tested by the contractor, under the direction of said inspector of the Railway Company, to 18,000 lbs. per square inch of sectional area.

On completion, the bridge, after being in current use for one day, will be tested with trains loaded approximately to the maximum specified, and after remaining on the spans for thirty minutes and then removed, no permanent set should take place.

False Works, etc.—The Railway Comany will remove the present single track wooden bridge on the site of the proposed structure, support the track on a pile bridge, and build the masonry centre pier and abutments of such dimensions and heights as will meet the requirements of the said structure. Will furnish and put in the lower falsework for erecting the new span, and also furnish the necessary timber for the upper false work. The work of erecting the upper false work and also of the structure, shall be done by and at the expense of the contractor, without interfering with the passage of trains, and under regulations to be approved by the Superintendent of the Railway Company.

The upper false works necessary for erecting the structure shall be removed by and at the expense of the contractor on completion of the work. The lower false works will be removed by the Railway Company.

The Railway track iron and cross ties will be furnished and placed in the structure by the Railway Company.

APPENDIX B.*

NOMENCLATURE AND CLASSIFICATION OF MASONRY.

A careful analysis of a large number of masonry specifications has revealed the fact that serious discrepancies exist in the use and meanings of the terms employed to designate the several classes and grades of work, giving rise to misunderstanding between the contracting parties. It is the object of this paper to attempt the removal of these ambiguities by comparing carefully the numerous authorities available, and stating the conclusions obtained in such form as may be readily referred to.

In the preparation and manipulation of stones for building purposes three classes of artisans are employed, viz.: the *quarryman*, the *stone-cutter* and the *mason*. It is the duty of the first to detach the stone from its natural or quarry bed, in a rough state, constituting *rubble*; of the second, to reduce the mass to prescribed dimensions with a specified finish, constituting *cut* or *dressed stone*; and of the third, to lay the stone with its proper bed and bond in the structure, constituting *masonry*.

Hence arise two general classes of masonry—one based upon the preparation of the individual stones, or *the finish*, and the other, upon the method of laying, or *the bond*. The first of the above classes naturally resolves itself into the subdivisions of CUT OR DRESSED and UNCUT OR ROUGH stones. The second may also be subdivided into masonry, in which the horizontal joints are *continuous* throughout the structure, or REGULAR COURSED; and that in which they are *not continuous*, but broken in offsets, constituting IRREGULAR-COURSED OR RANDOM MASONRY.

In designating masonry, therefore, it is seen that to give a clear idea of the kind intended, not only the *bond* but the *finish* should be distinctly specified, and care should be taken that there be no ambiguity in regard to the ordinary meanings of the terms used.

The terms ashlar and rubble do not appear to be clearly understood, and even the authorities are not in perfect accord on this subject. In a paper read before the American Society of Civil Engineers, November 7th, 1877, by Messrs. Croes, Merrill and Van Winkle, ashlar masonry is defined to be "Equivalent to cut-stone masonry. * * * As a rule the courses are continuous, but sometimes they are broken by the introduction of smaller stones of the same kind, and it is then called *broken ashlar*. * * * From this derivation, ashlar apparently means large, square blocks, but practice seems to have made it synonymous with 'cut-

* Extracts from a paper read before the Engineers' Club, of Philadelphia, by Prof. L. M. Haupt.

stone,' and this secondary meaning has been retained for convenience." And the same authorities define "cut-stone" to be those which are "squared and have smoothly-dressed beds and joints." Another authority defines ashlar to be composed of "stones dressed and pitched well and properly so that the *face* of each be a polygon of straight sides not to exceed *six* in number." This is called *broken* ashlar; but if ashlar be *squared* stone, as above defined, this class must be excluded; and since it is more than rubble, having the *joints dressed*, it must belong to the genera of "cut stone;" yet according to the definition given by the committee of the American Society of Civil Engineers the joints should be at right angles or squared, which they are not, hence it is desirable to make a distinction between ashlar and "cut-stone" by omitting the word *squared* from the definition of the latter, and calling the work just described *dressed rubble*. By so doing it is excluded from the species ashlar, yet included in the genera "cut-stone."

It would appear then that definitions based on the relative position and kind of joints would preserve the distinction between the two grand divisions of ashlar and rubble. So long as the stones are "squared," that is, having beds and vertical joints at right angles to each other, the masonry built of them is *ashlar*, whether the courses be continuous or not. If continuous and of equal heights it is "*regular ashlar*," if discontinuous it is "*broken-range*," "*irregular*," or "*random ashlar*." (These three terms are practically synonymous.) If continuous but of unequal height it is simply *range work* or *block-in-course*.

If the stones are *not* "squared" but have hewn joints perpendicular to the face, and making any angles with each other, it is "*dressed rubble*," and if unhewn or in a natural state, simply "*rubble*." The face of "dressed rubble" may be hewn, pitched, or rough.

Ashlar.

Gwilt defines ashlar as "common or freestone, as brought from the quarry—also the facing given to square stones on a front of a building." Webster quotes from Gwilt.

Rankin says, ashlar or hewn stone, consists of blocks of regular figures, generally rectangular, and built in courses of an uniform depth, seldom less than one foot.

Burn, in *Working Drawings and Designs*, defines it as a facing of hewn and dressed stone given to walls, the back of which is rubble.

Knight, *American Mechanical Dictionary*, makes two classes: (*a*) *Rough*, a block of freestone as brought from the quarry. (*b*) *Smooth*, a block dressed ready for use.

Parker, in his *Glossary of Architecture*, is most explicit, and says it is hewn or squared stone, used in building, as distinguished from that which is unhewn or rough as it comes from the quarry; it is called by different names at the present day, according to the way in which it is worked, and is used for the facings of walls, and set in *regular courses as distinguished from rubble*.

BRANDE and COX define ashlar as being stone reduced to a rectangular form; and

TOMLINSON, as stone squared and dressed to given dimensions.

RUBBLE.

PARKER defines rubble as "stones not large but irregular in size and shape, and not so flat-bedded as in rag work; it is generally used for the backing."

American Encyclopædia, as coarse walling of rough stones.

BRANDE and COX, as any stone broken from the quarry in rough, irregular masses, and not subjected to any further dressing.

TOMLINSON, stones used without being squared.

From the authorities already quoted it is evident that the chief distinction between ashlar and rubble consists in the shape of the stone, the first being squared, the second *not*; and yet we find a reliable authority defining dressed *rubble* as consisting of *squared* stone (not less than 18 inches high, with no bed less than 18 inches or less than the height of the stone). The term is a misnomer, as such masonry should be classed under the generic term ashlar and may be either *range-work*, *random* or *irregular ashlar*, or "*rock-face pitched ashlar*, *etc.*, according to circumstances.

Another authority says "*rubble* will be built of stone at least nine inches thick, and each stone must have one-fourth more bed than rise, and a length not less than twice nor more than four times the rise. The coursing may be irregular." The stones herein described are evidently squared and consequently cannot properly be classed as rubble.

In addition to the laxity existing in the use of terms, another source of trouble arises from the introduction of impossible conditions concerning dimensions. For instance, the specifications for first-class bridge masonry used on an important railroad, read as follows:

"Courses of stone in abutments, piers and walls are to be not less than *ten* nor more than thirty inches thick. *Stretchers* to be not less than two and a half nor more than six feet long and not less than one and a half feet wide, nor less in width than one and a fourth times the depth." This would make the least allowable depth 14.4 inches, whereas above it may be 10 inches. Again, "*headers* must not be less than three and a half feet nor more than four and a half feet long, where the thickness of the wall will admit the same, and not less than *one and a half feet wide* nor less in width than they are in depth of course. The *joints*, well broken, in no case less than *twelve* inches." These requirements give as the least width of header 1½ feet, and for lap of joint 12 inches on either side, making two feet more or 3½ feet for least allowable length of stretcher, whereas above it may be but 2½ feet.

Since masonry is also specified as first, second and third-class, it is desirable to prescribe if possible the characteristics of these various classes.

The requirements of FIRST-CLASS MASONRY are found generally to be as follows:

Courses not less than twelve nor more than thirty inches in height.

Stretchers not less than four and a half nor more than six feet long, height equal that of the course, and width one-fourth greater than the height for courses under 16 inches, and where course is greater it should at least be equal to height.

Headers not less than three and a half feet long (unless in a narrow wall); height equal to that of the course, and width equal to height. The headers should occupy from one-fifth to one-third the face of the wall.

Joints should not be more than three-eighths of an inch wide, and the vertical joints should be dressed back at least one foot from the face. The beds should be dressed true and out of wind. If the surface be "rock-face" it should be pitched and the projections should seldom exceed four inches, though the limits vary from one to six. It is frequently drafted.

In SECOND-CLASS MASONRY the stones are smaller and need not be laid in continuous courses. It, therefore, includes random, broken-range and irregular ashlar. The joints are not so closely dressed, varying from ⅜ to ¾ of an inch, but should be horizontal and vertical.

THIRD-CLASS MASONRY consists of rubble either dressed or rough, but well scabbled and with close joints well filled with mortar and small stones (chips or spalls). There should be no spaces greater that six inches to be filled with mortar.

Many combinations may be made of bond and finish, as rock-face pitched ashlar, regular-coursed smooth ashlar, regular-coursed polished ashlar, random-coursed toothed ashlar, etc.

There are also other classes of masonry, based upon its use, as arch culvert, box, etc., to which the preceding remarks may be readily applied.

MASONRY.

A structure of stone or brick-work, laid either dry or with mortar.

CUT OR DRESSED, having at least the joints and beds hewn.			UNCUT OR ROUGH, as blasted from the quarry.	
(A) CLASSIFIED ACCORDING TO *BOND.*				
ASHLAR.			RUBBLE.	
1. REGULAR ASHLAR; squared and laid in horizontal courses of equal heights.	2. RANGE-WORK or BLOCK-IN-COURSE; differs from *regular* only in having courses of less height (7″—9″).	3. IRREGULAR, BROKEN-RANGE or RANDOM; squared stones laid in irregular courses of variable height.	1. COURSED; laid in rough courses, without having joints vertical.	2. ROUGH; laid at random.

(B) CLASSIFIED ACCORDING TO *FINISH.*

ASHLAR.

AXED; dressed to a plane surface with an axe.

BASTARD; a term sometimes applied to combination walls, the face being ashlar; back, rubble.

BOASTED or CHISELED; having face wrought with a chisel or narrow tool.

BROACHED; dressed with a "punch" after being droved.

BROKEN; six-sided (improperly used. See dressed rubble).

BUSH-HAMMERED; dressed with a bush hammer.

CRANDALLED; wrought to a plane with a crandall.

DIAMOND work; that in which the face is formed by four planes meeting at the intersection of the diagonals.

DRESSED work; that which is wrought on the face.

DRAFTED; having a narrow chisel draft cut around the face or margin.

DROVED, STROKED; wrought with a broad chisel or hammer in parallel flutings across the stone from end to end.

HAMMER-DRESSED; worked with the hammer.

HERRING-BONE; dressed in angular flutings.

NIGGED, NIDGED; picked with a pointed hammer or cavil to the desired form.

PATENT-HAMMERED; dressed with a patent hammer.

PICKED; reduced to an approximate plane with a pick.

PITCHED; dressed to the neat lines or edges with a pitching chisel.

PLAIN; rubbed smooth to remove tool marks.

POINTED; dressed with a point or very narrow tool.

POLISHED; rubbed down to a reflecting surface.

PRISON; having surface wrought into holes.

RANDOM-TOOLED or Droved; cut with a broad tool into irregular flutings.

ROCK-FACED, QUARRY-FACED, ROUGH; left as it comes from quarry. It may be drafted or pitched to reduce projecting face to given limits.

RUBBED; see plain.

RUSTIC, RUSTICATED; having the faces of stones projecting beyond the arrises, which are beveled or drafted. The face may be dressed in any desired manner.

SMOOTH; see plain.

SQUARE-DROVED; having the flutings perpendicular to lower edge of stone.

STRIPED; wrought into parallel grooves with a point or punch.

STROKED; see droved

TOOLED; wrought to a plane with an inch tool (see droved).

TOOTHED; dressed with the tooth chisel.

VERMICULATED, WORM WORK; wrought into veins by cutting away portions of face.

RUBBLE.

ROUGH; unhewn stone as taken from quarry.

DRESSED; having the joints wrought to a plane surface, but not "squared."

MISCELLANEOUS.

BETON, CONCRETE; an artificial substance composed of broken stones, bricks, shells or other minerals, of various sizes, mixed with sand, cement and water in various proportions.

RIP-RAP; an apron or revetment of rubble stone loosely thrown into position.

RAG WORK; masonry of small flat spalls of slates or shales laid in mortar.

GLOSSARY

OF TECHNICAL TERMS USED THROUGHOUT THIS WORK.

A

Abutment—That portion of the masonry of a bridge or dam upon which the ends rest, and which connect the superstructure with the adjacent banks.

Air Registers—Ventilators of iron or other material, covering apertures in walls, windows, or doors, to permit a free circulation of air.

Angle Iron—A strip of flat bar iron bent longitudinally at right angles.

Arch Caps—Voussoirs.

Architrave—The lowest, principal division of an entablature, resting immediately over the abacus.

Arris—The edge in which two surfaces meet; the intersection of two planes.

Ashlar—In masonry a stone squared and hewn, used for facing work when laid in regular beds or joints. Tooled ashlars are blocks marked with parallel flutings or grooves.

Axed—in masonry, dressed with a stone hammer to a smooth surface.

B

Backed—In masonry, built in on the rear face.

Backed—In carpentry, is applied to joists having their upper surfaces hewed or planed off near the ends, decreasing to the middle, causing them to be slightly round on top, to allow for settling.

Backed—In earthwork, filled, returned to place.

Baluster—A small pillar supporting a rail.

Balustrade—A raillng composed of balusters.

Base—Lower portion of a post or column, but is generally used to designate the lowest portion of any structure.

Basil—The angle at the cutting edge of a tool or instrument.

Bats—Broken bricks.

Batter or batir—The slope or inclination given to the front or face of a wall. It is expressed by dividing the height by the horizontal distance from the vertical to the face; thus $\frac{5}{1}$ represents a slope of 5 feet vertical for every 1 horizontal.

Batten—A strip of board less than four inches in width, generally used for covering cracks or joints.

Battlement—A notched or indented parapet, of which the higher parts are called *merlons*, and the openings or lower portions, *embrasures* or *loops*.

Bay—in plastering, the distance between the screeds.

Bay window, (*auriel* or *oriel*)—A window forming a bay or recess in a room, often corruptly called a *bow* window.

Bead—A small round moulding, of semi-circular cross-section, called also *astragal.*

Beam—A general term to designate the principal horizontal timbers in a building. Its specific name is given by prefixing another term denoting its use or position, as *binding, collar, dragon, hammer, straining, tie,* &c.

Belt Stones or Courses—Horizontal bands or zones of stone encircling a building or extending through a wall.

Berme or Berm—A narrow level strip of earth or stone between two slopes.

Berm-ditch—A ditch just outside the berm, from which material has been taken to form an embankment.

Bevel or Splay—A sloped or inclined surface making with adjacent surfaces an angle different from a right angle.

Binders—In masonry, stones extending through a wall or from the faces well into the filling or heart to unite the portions more firmly.

Blasting—Displacing rock or hard material by the use of an explosive agent.

Blocked Apart—Held apart by small blocks or keys of hard wood.

Blocked—Having triangular blocks glued in the angles to prevent change of form.

Blockings—Pieces of material used to raise barrels, &c., off the ground, to prevent deterioration of the contents from dampness.

Block Plan—A general plan showing relative positions of objects on a comparatively small scale.

Blocks—Pieces of material cut into a prescribed form for a particular purpose.

Board Measure—The measure used in estimating the contents of lumber. The unit is a square foot of surface one inch thick or 144 cubic inches.

Body Bound.—Fitting so snugly as to have to be driven into place, as in bolts, &c.

Bolster Blocks—Plates on the lower side of a bolster to diminish the friction, as in a bridge seat.

Bond—The manner of arranging the materials in masonry, so as to unite the parts firmly.

Bonus—A consideration; a premium or award offered for work completed before a given time, hence it has become the synonym for work which has been hastily and improperly done.

Borrowed—In earthwork; when the materials furnished by the excavation is not sufficient to form the embankment, the deficiency is supplied from points off the road bed. Such material is said to be borrowed.

Borrow Pit—The excavation from which borrowed material is obtained.

Boss—In architecture, a projecting ornament placed at the intersection of the ribs of ceilings; a projection.

Box Frames—Hollow wooden sash frames.

Brace—An inclined member of a frame or truss. It may be subjected to strains of compression, when it is a *strut,* or of tension, when it is a *tie.*

Bradded—In glazing, fastened in with brads.

Bronze Furniture—A term applied to door knobs, washers, escutchions, &c., when of bronze.

Build—In masonry, that dimension of the stone which is perpendicular to the quarry bed.

Bull's Eye—A small round window, or light; a lantern.

Buoy—A floating body of wood or iron used to indicate a ship channel, or an obstruction.

Burnished—Rubbed smooth with a trowel.

Bush Hammer—A mason's large breaking hammer.

Butt—A term applied to the ordinary door hinge.

Buttress—A projection built against the *outside* of a wall to increase its stability; when placed on the inside it becomes a *counterfort.*

C

Camber—A slight vertical convexity given to a truss to stiffen it.

Cantilever, Cantaliver or Cantiliver—A projecting timber in one piece, used as a bracket to support eaves, cornices or balconies.

Caps—Coverings, usually of stone or wood.

Capital—The head or top of a column.

Cappings—The flat stones covering buttresses, gables, &c.

Cast—(Commercial) computed.

Catamaran—A heavy four-wheeled wagon for transporting large blocks of stone.

Ceiling—In plastering, on laths.

Centre / Centering —A frame of wood or iron for supporting arched mason work.

Centre Pieces—Ornamental bosses of plaster usually attached to ceilings.

Chairs—Castings used to support the ends of rails or timbers.

Chamfer—An arris or edge which is pared off, beveled.

Channel Bar—A wrought iron bar having its edges turned up at right angles, making a square trough.

Cheek Blocks—A block one side of which is formed by the cheek piece secured to a fixed object forming the other side.

Chipped—Having small pieces or spalls broken off the edges.

Chipping Piece—The projecting piece of iron left on a casting for the purpose of fitting it to another.

Chisel Marked—Having notches or indentations cut by a chisel to show the position of pieces in the structure.

Circular Work—In carpentry, all work the surface of which is curved.

Cleat—A strip of wood fastened to another to strengthen it, or a belaying piece.

Clerestory or Clearstory—Any window or row of windows in the upper part of a building, usually applied to the upper part of the central aisle of a church in which the windows overlook the roofs of the side aisles.

Coffer-dam—A temporary dam built around a pier or shaft in water and made water tight by puddling.

Coils—Rope laid up ring fashion, flake on flake.

Concrete—A composition of broken stone, cement and sand possessing the property of setting, and used largely for foundations or filling.

Conductors—lines of water pipes leading from the roof to the well or drains.

Constructive measurements—Allowances extras.

Container,—A pan placed in water-closets to hold a supply of water.

Coping Stones—Large flat or sloping stones forming the uppermost course in a wall used as a protection from the weather.

Copper Planished—Copper lined with tin.

Corbel—A projecting stone or piece of timber supporting a superincumbent weight.

Cornice—The horizontal moulded projection terminating a building, or the component parts of a building.

Counterhewed—Dressed with an adze to a true surface.

Countersink—To let in, as a screw, so that the head shall be even or flush with the surrounding surface.

Coupling—A device for uniting adjacent parts or objects.

Covering—In culverts, the large stones extending across the top from side to side and resting upon the walls.

Cradle—The rubble masonry built around and below the haunches of an arch in sewers, &c.

Cresting / Crest Railing—The railing surmounting the ridge of the roof of a building.

Cross Bridging—Short battens placed in the form of an X between joists to stiffen them and prevent twisting.

Cross Section—The section made by cutting across or through an object.

Cross Section Paper—The paper used for plotting the cross or transverse sections of earthwork upon.

Crown—The highest point in the curve of an arch.

Culled—assorted, picked out, selected.

Cut Stone Masonry—That built of stones having plane joints and smooth or dressed faces.

D

"Dashed and Broomed"—Having mortar thrown against the surface to be covered, and smoothed down with a broom.

Davits—The iron brackets or cranes hinged upon a vessel or balcony for the purpose of raising boats or weights.

Deck Bridge—One in which the track bearers rest upon the upper chord and the trains pass over the top.

Deafened—So arranged as to interrupt the passage of sound.

Dentils—Ornaments resembling teeth, used in the mouldings of Ionic, Corinthian and Composite cornices.

Derrick—A kind of crane having a hinged jib or arm which can be raised or lowered at pleasure.

Diagonals—Boards or laths nailed on the studding diagonally.

Diamond Checkers—Diamondshaped cavities or projections in an iron floor to roughen It.

Dimension Stone—Is that which is quarried of such sizes and shapes as to have, when dressed, certain given dimensions.

Door Jamb—The vertical portion of the frame; the sides.

Dormers—Windows pierced through inclined roofs and having their frames vertical.

Double Hung—Windows having two sashes separated by parting strips.

Double Trimmers—Two parallel joist arranged to receive aud support others called tail joist at right an les to them.

Dowel—A straight pin of wood or metal inserted part way into each of two faces which it unites.

Drafts—In stone cutting, are lines cut upon the faces to be used as guides in dressing or laying.

Drafted—Having drafts cut upon the surface.

Drawn—Removed, pulled out.

Drift Bolts—A rod used to drive out a bolt.

Dump—An embankment where material is deposited from carts, cars or barrows.

Dump Scow—A bateau having a movable bottom.

Dumping Ground—Any site where waste material or refuse may be deposited.

E

Eaves—That portion of a roof which projects beyond the walls.

Extrados—The exterior curve of an arch, measured on top of the voussoirs.

F

Facade—The exterior face or front of a building.

Fall—The rope used with pulleys in hoisting.

Fascia—A broad fillet, band or face used in classical architecture, generally in combination with mouldings.

Fence Stone.—Long rectangular stones suitable for fence posts.
Fillet—A small flat band used principally between mouldings to separate them.
Finial—The carved or ornamental terminal inserted in gables, canopies, &c., in Gothic architecture.
Flagstones or Flags—Large flat slabs used for paving.
Flashings—Broad strips of sheet lead, copper or tin having one edge inserted in the joints of brickwork or masonry, an inch or more above a roof. The opposite edge is flattened down upon the roof and covered by slate shingles, &c., to prevent leaks.
Flat Work—In plastering, is that having no projections, beads or mouldings.
Flatted Timber—That which is hewn or sawed on two sides only.
Float—A plasterer's trowel, used in *floating* plaster on a wall. It is sometimes so long as to require two men to use it.
Flush—Even with; being upon the same level.
Flush Bolt—A screw bolt whose head is sunk to the level of the surrounding surface; a sliding bolt let into the face or edge of a door.
Flume—An artificial channel for conducting water around or through a piece of work in progress.
Footings—The bottom of a trench for foundations.
Frieze—The middle division of an entablature in architecture, lying between the architrave and the cornice.
Function—A quantity or expression depending for its value upon that of some variable which it contains.
Furring—Pieces inserted to bring others up to a required level as in joists; a kind of chock.

G

Gable—That portion of the end wall of a building above the eaves of a sloping roof.
Girder—A beam which sustains the joists of a floor when the distance between walls renders additional support necessary.
Girth or Girt—The periphery or bounding line limiting a right section of any body.
Grillage—A platform of heavy timber notched together to support a structure in compressible soils.
Grouting—A thin mortar or cement poured into the joints of masonry and brick work to fill the interstices.
Grubbing—Removing roots and stumps from the surface; clearing.

H

Halved—In carpentry, cut half away so that two timbers may pass each other and yet have their faces in the same planes.
Hammer-Dressed—Dressed to a plane surface by repeated blows of the patent dressing hammer.
Hanger—An iron bracket or projection depending from a ceiling for supporting shafting.
Hard Pan—A stiff clay which it is sometimes necessary to remove by blasting.
Hatchings—In topographical drawings, are shade lines drawn in the direction of falling water to indicate the direction of the slope. Its angle or intensity is represented by the number and thickness of such lines in a given length of contour.
Haunches—Those portions of an arch lying between the crown and the pier or abutment.
Headers—Those bricks or stones having their ends in the face of a wall and their lengths perpendicular thereto.
Heading—In tunneling, a gallery or drift excavated in advance of the bottom to facilitate the work.

Head Light—The light carried in front of a locomotive to illumine the way and act as a signal.

Head Shaft—The main shaft connecting directly with the engine.

Hearting—The interior filling of a wall.

Hip Roof—One that slopes four ways, forming ridges or hips.

Hollow Quoins—Cylindrical recesses or corners in canal locks in which are placed the posts of the gates.

Honey Combed—Vesicular, spongy, full of holes.

Hood—A cap or covering of stone, metal or wood.

Horses—The inclined notched ribs which support the steps in a staircase.

I

Impost—The horizontal block of masonry at the point of junction between the arch and its piers.

Isometrical—Of equal measure; in drawing it is that method of representing objects on the flat by which their three dimensions are laid off upon three axes making with each other angles of 120° and the scale is the natural cosine of the angle made by the edges of a cube with a plane perpendicular to its diagonal.

Invert—An arch built on the ground, concave upwards, to support piers or walls and distribute the superincumbent pressure.

J

Jambs—The side of a door, window, chimney, &c.

Jettee or Jetty—A pier, mound or mole projecting into the water to protect a harbor or river bank.

Jogs—In masonry indents or offsets either in the stones themselves or in the manner of laying them.

Joist—Timber used in supporting floors and ceilings.

K

Knees—Crooked timbers used in ship building for uniting the ribs to the deck timbers; any angular pieces of wood or metal similarly applied.

Keystone—The top stone or voussoir at the crown of an arch.

L

Laterals—The braces in the side of a truss.

Lathing—The thin strips nailed to the studding to support the plaster.

Lead—The length of haul from the pit to the dump.

Lining—The arch of a tunnel or culvert.

Lintel—A horizontal beam over an opening in a wall; when the span is great and the beam supports heavy masonry, it is called a *breastsummer* or *bressummer*.

Light—A pane of window glass.

Lock—A chamber of masonry closed at the ends by gates to pass boats from one level to another in canals.

Lock-pit—The excavation for the masonry of a lock chamber.

Lumber—Sawed timber, either boards, plank or squared pieces.

Lugs—Small projections upon the surface of a casting by which it may be lifted or fastened in place.

M

Manhole—An opening into a sewer, drain or culvert large enough to admit a man.

Manilla—A fibre obtained from the *Musa textilus* in the Philippine Islands, used for making ropes and paper.

Mantel—A covering.

Maul—A large mallet of hard wood bound with iron rings.

Mean Low Water—The mean height of low tides, and the datum surface to which geodesic levels are referred.

Meeting-Rail—The central vertical rail of shutters.

Mineral Furniture—Knobs, escutcheons, &c., made of clay, porcelain or other mineral substances.

Mitre—The line formed by the intersection of mouldings, beams or parts of a frame meeting at an angle.

Mitre Sill—The sill against which lock gates rest when closed.

Mitre Posts—Those meeting over the mitre when the gate is closed.

Modillions—Projecting brackets under the corona of the Corinthian and composite orders.

Mortise—A hole or recess cut in the face of a timber to receive the *tenon* projecting from the end of another.

Moulding—A general term given to all linear ornaments whether projections or cavities, as the fillet, bead, ogee, &c.

Muck—Soft mud containing much vegetable matter.

Muck-Bar—Bar iron which has passed once through the rolls. It is usually cut into lengths, piled and re-rolled.

Mullions—The vertical strips separating window panes.

Muntins—The horizontal strips separating window panes.

N

Nave—The part of a building in which the audience assembles.

Neat Lines—Those by which the work is laid out.

Neat Work—Work wrought to the neat lines.

Newel—The central column around which the steps of a circular stairway wind; the principal post at the angles and foot of a staircase.

Normal—Perpendicular to any surface or line

Nosing—The slight projection upon the front edge of a step or window sill.

O

Ogee—A moulding of an S shape.

One-Man-Stone—A stone of such size as to be readily lifted by one man.

Out of Square—Askew, oblique.

Out of Wind—Perfectly straight or flat.

Outlets—Openings through which gas pipes enter rooms.

P

Parget—The plastering applied to the interior surface of chimneys.

Pediments—That portion of the end wall of a building which corresponds to the gable; but it is much less acute at the top. The term is often applied to the triangular decorations over doors and windows.

Parting Strips—The thin vertical strips in a window frame to separate the sash.

Pinnacle—A shaft surmounted by a small spire and finial.

Pilaster—A square column or pillar generally attached to a wall from which it projects a third, fourth, fifth or sixth of its breadth. It is sometimes disengaged.

Pin Connections—The iron pins used in uniting the several members of a bridge or roof truss at the posts.

Pinners—Small stones driven into joints to wedge others.

Pinned—Held in place by wooden pins or tree nails.

Pit—A hole or excavation from which material has been removed.

Pitch—The slope of a roof, inclination, distance between teeth of a cog wheel or the threads of a screw.

"Pitched"—Chiselled to a line; also rubble work in which the blocks are *pitched* into place with a certain degree of regularity, so as to bind one another in place. As in the upper courses of breakwaters, jetties, &c.

Plant—The general arrangement of the machinery in any manufactory or process; the tools and apparatus required in any operation.

Plancier—The soffit or under side of the corona of a cornice in classical architecture.

Plinth—A square member forming the lower division of the base of a column; also the plain projecting face at the bottom of a wall.

Plumb—Vertical, upright

Pointed—Dressed with a point and mallet to true planes; also having joints filled with cement or mortar and lined with a trowel or pointing tool.

Primed—Having the first coat of paint or "priming" laid on.

Porcelain Furniture—Knobs, &c., of porcelain.

Purlins or Purlines—The horizontal strips placed upon rafters to support the roof covering.

Q

Queen-Posts—The two vertical members of a roof truss composed of two struts and a straining beam, ties and rafters.

Quoin—The hollow into which the quoin post of a canal lock gate fits; also the dressed stones on the vertical edges of buildings.

R

Racked Back—Built in steps or offsets out of plumb.

Radiators—Coils or drums used in heating by steam or hot air.

Rabbet or Rebate—A half groove along the edge of a board or moulding forming a longitudinal recess.

Raked Out—Cleaned out with a scraper.

Range Work—Built in horizontal layers of uniform thickness.

Relieving Arches—Those built against the back of a wall and having their axes perpendicular thereto to relieve the wall from the pressure of a backing of earth.

Rendering--Plastering on a wall without laths.

Registers—The open work castings inserted in walls for air passages.

Return—The termination of the drip stone or hood-moulding of a window or door.

Return Walls—Wing walls used to support the side slopes of an embankment and keep open a passage way.

Reveal, Revel—The sides of an opening for a doorway, window, &c., between the framework and the outer surface of the wall.

Ridge—The line in which the slopes of a roof meet.

Ring—To make a sonorous vibration.

Rip-Rap—A covering or apron of rubble stones thrown over a bank to protect it from washing,

Riser—The vertical part of the face of a step.

Rock Range Pitch Face—Masonry with roughly scabbled faces, but with "beds" and "builds" cut square and true.

Rock Face—Not dressed or hammered to a plane on the face.

Rostrum—An elevated platform in a hall, with a sedilia.

Rough Cast—A mode of finishing outside work by dashing over the second coat of plaster while quite wet, fine washed gravel in lime.

Rubble Work—Masonry in which stones are used in the rough without being dressed to size.

Running Foot—A foot measured in the direction of the length of the material, without reference to the other dimensions.

S

Saddle Heads—Hollow castings resting on the heads of columns to sustain another series above and allow beams to pass through.

Salmon Bricks—Pale yellow, underburnt bricks.

Sand Finish, Floated—Plastering in which the finishing coat is composed chiefly of sand put on with the float and straight edge.

Sash—The frame of wood or iron supporting the glass in windows.

Sash Fasteners—The spring catches attached to the meeting rails to lock them.

Sash Lifts—The buttons or hooks attached to the lower rail of window sash.

Scabbled—Chipped off roughly with a stone hammer.

Scarf—A longitudinal joint made in timber by notching and overlapping their ends, which are secured by bolts, straps and fish-plates.

Scotia—A hollow moulding resembling a pulley.

Screeds—Strips of plaster both horizontal and vertical, forming guides for the straight edge.

Scroll—An ornamental form arranged like a band in undulations or convolutions.

Seasoned—Dried either by exposure to weather or by artificial means.

Second Shaft—The counter shaft connecting with the main or head shaft.

Secret Nailed—In flooring nailed through the tongue so that the heads of the nails are invisible.

Segmental Heads—Of doors and windows, arched so as to form an arc of circle.

Separators—Thimbles or small pieces of iron inserted between girders to keep them apart.

Set (n)—A permanent bend or deflection produced by straining a beam beyond its limit of elasticity.

Set (v)—Hardened—a cement, according to Vicat, is said to have set when it will bear a wire 1-24 in. in diameter weighted with one pound.

Shaft—A vertical pit or well; the main part of a column.

Shade—That part of an opaque object from which light is obscured by the object itself.

Shadow—That part of an object from which light is obscured by the interposition of an opaque body.

Shakes—Longitudinal cracks in timber which has grown in localities exposed to the wind.

Shank—The body of a bolt excluding the head; the long straight part of many things.

Skew-Back—The angular block supporting the end of an arched or inclined member.

Square Droved—In masonry, cut by a broad chisel into small lines square with the edge.

Splay—A surface making with another an angle differing from a right angle.

Stepped—Cut out in offsets resembling steps, as in foundation on sloping ground, &c.

Stiles (Styles)—In joinery, the upright pieces of a frame as of a door, shutter, screen, or other panel work. The horizontal pieces are termed rails.

Stop-Bead—A small bead or projection on a metal surface to prevent a pipe or sash from slipping past.

Straining-Beam—A horizontal beam placed between two struts inclined in opposite directions, producing a strain of compression.

"Straw" Bids—Fraudulent bids.

Strapped—Bound around with flat bands of iron.

Stretchers—Bricks or stones placed with their longest dimensions parallel to the face of a wall.

String Course—A projecting horizontal band or line of mouldings in a building.

Stringers—Longitudinal beams generally used to support a uniform load.

Stripping Grounds or Grounds—Strips of wood fastened to blocks in a wall to support architraves and mouldings.

Struck Joints—Those filled with mortar which is pressed out and struck off with a trowel.

Struck Measure—One in which all material projecting above the top of the vessel is scraped off.

Stirrup—A pendant band of iron, supporting girders.

Stud—A short stout projecting pin; a prop; the vertical pieces in a stud partition.

Sub-Panel—One of the lower panels in a door, &c.

Sub-Plinth—The lowest portion of the plinth.

Suites—Adjoining apartments.

Swedged—Hammered with the swedge hammer which has a cylindrical groove of proper diameter traversing its butt.

Swivel—A revolving link in a chain consisting of a ring or hook ending in a headed pin which turns in a link.

T

Tail Joist—Short pieces of joist extending between two beams, girders or trimmers.

Tap Screws—A screw of hard steel with a square head for cutting threads on nuts.

Tap Bolt—A bolt which simply passes into its socket without penetrating it.

Tapped—Reamed out.

Templet or Template—A form or pattern.

Tenon—A projection from the end of a timber made to fit a mortice.

Terra Cotta—A substance manufactured from clay and sand or chamotte (ground terra cotta.)

Thimble—A short piece of tube slipped over a rod to separate parts of a structure as, a post or chord.

Through Bridge—One in which the vehicles pass through, the road bed being supported on the lower chord.

Thickening Washers—Additional or extra washers used when the thread is not cut far enough on a bolt.

Topped Out—Having a splay outward at the top as in chimneys.

Toothing—Unfinished brickwork so arranged that every alternate brick projects half its length.

Tool Dressed—Hammered to a plane surface, not smoothed.

Transept—That part of an auditorium which projects at right angles to the body or nave, making it cruciform.

Transom—A horizontal cross bar or mullion for a door or window usually separating the door from a light over head.

Trap—A horizontal door, as in a floor; a bend in a pipe to retain water and prevent foul gasses from flowing through.

Tread—The flat or horizontal part of a step.

Treenails—Wooden pins used in fastening timbers together.

Trimmer—A short cross timber, framed into two joists to sustain the ends of intermediates where they would otherwise find no support.

Turn Buckles—A small fastening turning about a screw through its centre; a nut with a right and left handed screw for tightening up tie rods.

Two-Men Stone—Stone capable of being conveniently lifted by two men.

Three Coat Work—Plaster or paint put on in three layers.

Tongued and Grooved—Having a rib projecting from the edge of one board and fitting a corresponding longitudinal recess in another, as in flooring.

U

Upset (or Stove Up)—Hammered back to thicken the end of an iron bar as in forming an eye or head for a bolt.

V

Valley—A re-entrant angle formed by the intersection of two parts of a roof.

Veneered—Covered by a thin sheeting of ornamental wood.

W

Wainscoting—A wooden facing around the walls of rooms about three feet high.

Wall Plate—The plank laid on the side walls of a house on which the roof trusses rest.

Wash Boards—The boards surrounding a room, at the floor, to a height of less than a foot.

Wasted—Thrown aside.

Water Closet Containers—The basins above the goose neck forming a trap.

Water Table—A horizontal band or offset in a wall sloped on the top to shed the water: usually between the foundation and superstructure.

Weather Boarding—An outer covering of boards which are generally placed horizontally so that the higher board overlaps the one below, sometimes arranged vertically with battens over the joints.

Weir—An opening in the breast of a dam or an embankment to discharge the excess of water.

Weld—The junction of two metals made by heating and hammering them together in connection with a flux.

Web—The flat metalic surface connecting two or more ribs or flanges.

Wind—Twist, warp.

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ADDENDA.

ANNOUNCEMENT!

Department of Civil Engineering,

TOWNE SCIENTIFIC SCHOOL,

UNIVERSITY OF PENNSYLVANIA.

The *Course of Study* in this department extends over four years, the first two of which are regarded as preparatory, and embraces:

In the FRESHMAN YEAR,

The English, French and German Languages, History, Drawing, Mathematics and Chemistry.

In the SOPHOMORE YEAR,

Rhetoric, Compositions and Declamations, Philology, French, German, Drawing, Mathematics, Chemistry, Geology and Physical Sciences.

In the JUNIOR YEAR,

Logic, Compositions and Declamations, Physical Science, Geology, Chemistry, Mineralogy, Metallurgy, Mathematics, Surveying, Drawing, Architecture, Engineering and Modeling.

In the SENIOR YEAR,

History, International Law, Social Science, Compositions and Declamations, Astronomy, Physical Science, Geology, Chemistry, Mineralogy, Metallurgy, Drawing, Surveying, Geodesy, Engineering, Mechanics, Modeling and Architecture.

For requirements for admission and graduation, details of studies, tuition, &c., apply for the annual catalogue.

In addition to the above, instruction is given in the Towne Scientific School in five parallel courses, viz.:

I. Chemistry—*Dr. F. A. Genth.*
II. Geology and Mining Engineering—*Prof. J. P. Lesley.*
IV. Dynamical Engineering—*Dr. Wm. D. Marks.*
V. Architecture—*Prof. Thomas W. Richards.*
VI. A course preparatory to Medical Studies.

The remaining Departments of the University are those of Medicine, Law, Music and the Arts: for information concerning which application should be made to THE PROVOST.